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Ministry of Education, Youth and Sport
Department of Policy

Article

On the Relationship between Resource Allocation and Student Study Performance at Secondary Resource Schools (SRSs) in Cambodia

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Abstract

The present study aims to investigate the relationship between resource allocation and student performance at Secondary Resource Schools (SRSs) during the time period of the last five academic years, from 2015 to 2019. To date, no studies have examined the relationship or impact of budgets, infrastructures and human resource allocation on student performance at SRS in Cambodia. All secondary schools in Cambodia, a total of 1788, were included in the study. The five-year unbalanced panel data of 1788 secondary schools were extracted from the database of Education Management Information System (EMIS) of the Ministry of Education, Youth and Sport (MoEYS) for the analyses. Descriptive statistics and Pearson's Correlation were employed for the analyses. The analyses included 32 variables related to the allocation of budget, infrastructures, human resource and student performance in SRS. The findings showed that increasing schools with concrete structures, wooden structures and separate office space had significant correlation with student performance gains. Moreover, increasing teachers with lower secondary education, high school education, and post-graduate education strongly correlated with student performance gains over the five-year period. The results support the claim that resource allocation to SRS has been effective in the context of SRS in Cambodia.

***Keywords*:** Resource allocation; student performance; secondary resource school; Cambodia

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1. Introduction

The Secondary Resource Schools (SRSs) are highly anticipated by the Ministry of Education Youth and Sport (MoEYS), development partners, communities, and students to fulfill their role as a model schools which build human resources with knowledge, skill, and attitude. Quality of education will be essential in driving Cambodia from a lower-middle-income to an upper-middle-income country by 2030. The SRS is one of the vital strategic component for MoEYS in raising the quality of Cambodian secondary education. MoEYS (2008, p. 2) defines 'SRSs as schools that are equipped or provided with infrastructure and facilities, including buildings, meeting rooms, laboratories, libraries, computer room, audio-visual rooms, a source of electricity and water, and so on, and especially the provision of training to staff on how to use those infrastructure and facilities' (p.2). According to the Secondary Resource Schools Policy set out in 2008 and Secondary Resource School Monitoring and Evaluation Framework (MoEYS, 2018a), the management board, teachers, and students of the SRS shall act as role models for their communities and the surrounding areas. SRSs should function as network hubs in building cooperation, sharing experiences, and provoking solidarity among and between schools in their broader communities. The establishment of SRSs helps to: promote professional development for teachers; share best practices and experiences in teaching, learning, and management to network schools; introduce and implement school improvement plans; and, improve teacher competency through professional development and mentoring (MoEYS, 2008). Through the establishment of SRSs, it is only a prerequisite to achieving the actual expected outcome, which is the improvement of student learning outcomes in secondary education. A better student learning outcome is a primary endeavor of MoEYS as it is essential or augmenting human resources in order or the country to achieve its development ambitions by 2030 and 2050.

In supporting SRSs in Cambodia, investment in technical and financial support has occurred over the course of a decade. To date, many SRSs has been recognized for their rapid progress in teaching and learning development, especially with regard to student learning outcomes which clearly distinguishes SRSs from other types of secondary schools across the country.

The achievement of SRS has been observed to be a reflection of efforts in mobilizing infrastructure, budget, and human resources to raise student performance. Although this effort has been implemented for a decade, there has been no study on the impact of resources mobilization on school performance, the effectiveness of the resource allocation on student performance or learning outcomes, or the influence of resources allocation on other aspects of school-related improvement.

Therefore, this study aims to investigate the relationship between resource allocation and student performance over the past five years. This research seeks to explain if resources (including the development of infrastructure, human resources, and budget) have a positive and significant link with student performance. The study is guided by a research question, "What is the relationship between resources, including infrastructure, budget and human resource, and student performance at SRS in Cambodia for the last five academic years?"

The results of the present study can serve as empirical information for MoEYS and related stakeholders to more deeply understand the impact of their efforts in supporting SRSs for the last decade. It enables MoEYS to find the immediate and appropriate intervention to ensure the suitable development and improvement of SRSs. The findings will clearly reveal the effectiveness and efficiency of resource usage at SRSs so that network schools and other secondary schools can learn from the experience and best practices developed.

2. Literature review

Although the studies on separate student performance-related aspects are limited, several studies have investigated the relationship or effects of school resources on student performance (see Akey, 2006b; MacNeil, Prater, & Busch, 2009; Mortimore, 2001; Pov, Kawai, & Matsumiya, 2020; Uline & Tschannen-Moran, 2008) and drop-out (see Aaronson, Barrow, & Sander, 2007; Christle, Jolivette, Nelson, & education, 2007; Quinn, 2013; World Bank, 2005). In addition, many studies have shown a well-established connection between school climate and student achievement (see Hoy & Sabo, 1998; Uline & Tschannen-Moran, 2008). A positive school climate is a crucial factor in improving student achievement and attitude. Uline and Tschannen-Moran's (2008) studied the impact of quality facilities and school climate on student achievement. They showed that the school climate index had a significant link to student achievement. The findings also showed that school facilities had a significant and positive correlation with student achievement, while school climate itself was also linked to the quality of school facilities. Essentially, a healthy learning environment is a vital school-

climate is a vital variable for a healthy learning environment. MacNeil, Prater and Busch (2009) suggested that students would reach high achievement on standardized tests where healthy learning environments were maintained. Teaching methods and school atmosphere, which refers to school responsiveness and supportive environment, were the most significant predictors of student achievement.

On the other hand, school resources such as facilities and books also play a vital role in assisting students in learning, and studies over the past decades have revealed that resources have correlations with student achievement at school (see Coleman, 1966; Hanushek, 1981, 1986, 1989, 1991; Pov et al., 2020). There is also substantial evidence in the literature to strongly suggest how diverse school-climate variables affect student achievement (see Leithwood, Louis, Anderson, & Wahlstrom, 2004; Mortimore, 2001). Some other studies have found correlation between student achievement and other school-related variables such as teacher, school context, school resources, and principal leadership (see Akey, 2006b; Ma & Klinger, 2000; Schreiber, 2002; Stewart, 2007). However, according to a study in Cambodia on the impact of student-, family and school-related factors on student achievement, Pov et al. (2020) found that school-related factors had no significant impact on student achievement in the two-level Hierarchical Linear Model (HLM) models.

3. Methodology

This study investigated all secondary schools in Cambodia. The total number of schools was 1788. The unbalanced five-year panel data of SRS schools were extracted from Education Management Information System (EMIS) from 2016 to 2020. EMIS is responsible for collecting statistics related to educational indicators nationwide to document into its system annually. A report of statistics and indicators is published annually including MoEYS's raw data sources. The researchers decided to make a request to EMIS to provide data which consist of 32 indicators or variables related to four constructs of school progress and student performance, including a budget, infrastructure, human resources (teacher education/training), and student performance. All variables were in number and percentage (rate). Since the data in the current study are collected from the five-year unbalanced data, the average of each variable of each year was computed to represent each variable of each year for five years.

The study utilized Pearson's Correlation to analyze the data for examining the relationship between budgets, infrastructures, human resources, and student performance. Pearson's Correlation coefficient (r) was used to measure and explain the strength of the association

between variables, and the P-value (p) was presented to show the significant level of the coefficient (r). The data were divided into four constructs: budget, infrastructure, human resources, and student performance.

There were five variables of the budget construct, which focused on the sources of budget allocation to SRSs, including: schools with funds from the school; the schools with funds from the community; schools with funds from government; school with funds from abroad; and, schools with funds from NGOs. For infrastructure, there were nine variables utilized in the correlation models, such as: a school with concrete structure; the schools with wooden structure; schools without water; schools with a latrine; schools without a good floor; schools without a good roof; schools without good walls; schools with a separate office; and, schools with a separate library. For the human resource construct, the variables focused on the qualification of teachers working in SRS. Those variables were: teachers with primary education; teachers with lower secondary education; teachers with upper secondary education; teachers with post-graduate education; teacher with Ph.D.; and, teacher with pedagogical training. Lastly, student performance constructs consisted of 12 variables: number of students; repetition rate at lower secondary schools; repetition rate upper secondary schools; transition rate at upper secondary schools; net enrollment at lower secondary schools; net enrollment at upper secondary schools; the drop-out rate at lower secondary schools; the drop-out rate at upper secondary schools; the success of candidates in grade 9; successful candidate in grade 12, students completed lower secondary education and students completed upper secondary education. Variables related to infrastructure, budgets and human resources were utilized as independent variables, while variables related to student performance were used as dependent variables for analysis and interpretation.

4. Findings

The findings from using a Pearson's Correlation technique showed that there were some significant relationships between student performance and development of infrastructure and human resources as shown in the Table 1.

Correlation analysis found that the increased total number of students had the strongest positive correlation, which would be considered as a large effect size (see Abrami, Cohen, & d'Apollonia, 1988), with increased schools with a concrete structure (r=91, p<0.05), with teachers with a lower secondary education (r=99, p<0.01) and teacher with post-graduate education (r=92, p<0.05). This means that the number of students tends to increase in schools

with good infrastructures and teachers with at least lower secondary education. However, schools with wooden structures (r=-97, p<0.01) and teachers with high school education (r=-96, p<0.01) had a strong negative correlation with the increased total number of students. This means that student performance seems to decrease in schools with poor infrastructure although most teachers have a high school education. The repetition rate at lower secondary level was found to have a strong positive relationship with teachers with lower secondary education (r=92, p<0.05). On the other hand, the repetition rate at the upper secondary level was found to have a strong and positive correlation with schools with wooden structures (r=96, p<0.01) and teachers with upper secondary education (r=95, p<0.05). And, it had a strongly negative correlation with schools with concrete structures (r=-95, p<0.05), teachers with a lower secondary education (r=-91, p<0.05), and teachers with a post-graduate education (r=-99, p<0.01). It can be inferred that an increase in schools with wooden structures and teachers with upper secondary education will likely raise the repetition rate at the upper secondary level.

Moreover, an increase in schools with concrete structures, teachers with lower secondary education, and teachers with post-graduate education, will likely decrease the repetition rate at the upper secondary level. Furthermore, net enrollment at lower secondary schools had strong positive correlations with schools with a separate office (r=88, p<0.05), and with teachers with a lower secondary education (r=99, p<0.01). At the same time a strong negative relationship was found between net enrollment and schools with a wooden structure (r=-91, p<0.05) and teachers with an upper secondary education (r=-92, p<0.05). This means that an increase in schools with separate office and teachers with lower secondary education seems to escalate net enrolment at lower secondary level, but also that a decrease of school with wooden structure and teachers with upper secondary education seems to significantly foment net enrolment. Similarly, net enrolment at upper secondary schools had strong positive correlations with schools with a concrete structure (r=93, p<0.05), schools with a separate office (r=90, p<0.05), and teachers with lower secondary education (r=94, p<0.01). A strong negative relationship was found between net enrollment and schools with a wooden structure (r=-98, p<0.01), teachers with an upper secondary education (r=-97, p<0.01), and teachers with a post-graduate education.

In addition, the dropout rate at the lower secondary level was not found to have a significant correlation with any budget, infrastructure or human resource variables, but dropout rates at the upper secondary level were found to have a strong negative correlation with teachers with lower secondary education (r=-92, p<0.05). It means that at an upper secondary level, dropout rate tends to increase to the extent that a school has more teachers with only lower secondary education. Success of candidates in grade 9 had a significant positive relationship with schools with a concrete structure (r=99, p<0.01), and with teachers with a post-graduate education (r=96, p<0.05). Success of grade 9 candidates was found to have a negative relationship with schools with a wooden structure (r=-96, p<0.01), and with teachers with an upper secondary education (r=-91, p<0.05). This means that more students seem to pass the grade-9 exam when, compared to other schools, their schools have a concrete structure and more of their teachers have a post-graduate education. In a similar fashion, completion rates at lower secondary schools had positive correlations with school with a concrete structure (r=99, p<0.01) and teachers with post-graduate education (r=95, p<0.05), whereas it had negative correlations with schools with a wooden structure (r=-95, p<0.05) and teachers with an upper secondary education (r=-90, p<0.05). The completion rate was high for schools with a concrete structure and more teachers with post-graduate education, but it was low for schools with a wooden structure and more teachers with only an upper secondary education. Lastly, the results indicated that the completion rate at upper secondary schools had a strong positive correlation with teachers with lower secondary education (r=95, p<0.05), while had a negative correlation with schools with a wooden structure (r=-94, p<0.05) and teachers with upper secondary education (r=-91, p<0.05).

Table 1

Correlations of variables related to student performance with variables related to development of infrastructure and human resources for the last five years

N	Variables	School with concrete structure	School with wooden structure	School with separate office	Teachers with lower secondary education	Teachers with upper secondary education	Teachers with post-graduate education
1	Number of students	**.91***	**-.97****	0.83	**.99****	**-.96****	**.92***
2	Repetition rate at lower secondary schools	0.73	-0.80	0.75	**.92***	-0.81	0.87
3	Repetition rate upper secondary schools	**-.95***	**.96****	-0.72	**-.91***	**.95***	**-.99****
4	Net enrollment at lower secondary schools	0.81	**-.91***	**.88***	**.99****	**-.92***	0.83
5	Net enrollment at upper secondary schools	**.93***	**-.98****	0.80	**.97****	**-.97****	**.94***

6	Dropout rate at upper secondary schools	-0.85	0.84	-0.49	**-.92***	0.73	-0.83
7	Success of candidates in grade 9	**.99****	**-.96****	0.58	0.81	**-.91***	**.96***
8	Completion rate at lower secondary schools	**.99****	**-.95***	0.56	0.78	**-.90***	**.95***
9	Completion rate at upper secondary schools	0.87	**-.94***	0.80	**.95***	**-.91***	0.79

* $p < 0.05$; ** $p < 0.01$

5. Discussion

The results provide an in-depth understanding of the progress of student learning outcomes in line with the process of investment in resources at SRSs in Cambodia. It has been found that student performance had a strong and significant relationship with the facilities and the teacher qualifications at SRSs, during the time period of the past five academic years. The improvement and development of resources tend to significantly impact several student learning outcomes at SRSs. When schools are equipped with good buildings and have teachers with high qualifications, students tend to have a lower repetition rate, a higher net enrollment, a lower dropout rate, a higher number of successful candidacies in grade 9, and a higher completion rate in secondary education. The findings of the current study are also in line with several of previous studies (see Akey, 2006b; MacNeil et al., 2009; Mortimore, 2001; Uline & Tschannen-Moran, 2008), but they also contrast with some studies on the impact of resources on student achievement (see Coleman, 1966; Hanushek, 1981; Hanushek, 1986, 1989, 1991; Pov et al., 2020). This means that the implementation and support from MoEYS and other related stakeholders to SRS are effective and efficient in ensuring SRSs become a model secondary schools for network schools, schools in the community, and other secondary schools across the country. These laudable results would not have happened without the strong action and attention of the MoEYS, SRSs, and other related stakeholders for the past decade.

It has been observed that the positive outcomes for student performance at SRSs might derive from various efforts and reforms at the national and sub-national level, such as:

(1) Examination reform in the academic year 2013-2014: grade 12 examination reform has made a major impact on student learning outcomes through the notion of "you study, you pass". The examination reform agenda created a foundation of strict regulation, justice, and transparency which encourages students to study harder without thinking that advancement and success follow from cheating.

(2) Accept reality: the results of the examination in 2013 and the PISA-D (see MoEYS, 2018a) test in 2017 clearly indicate that essential interventions to improve student learning outcomes have become a part of the policy and strategy of the MoEYS and related stakeholders. A vital component of these efforts has been the establishment of SRSs because, according to the findings of the present study, they have significantly contributed to improvements in student learning outcomes.

(3) Secondary Resource School Monitoring and Evaluation Framework and standard test system: the monitoring framework and standard test system are the key pillars to ensuring transparency at the school level. They help to reveal the true quality of education to relevant stakeholders and especially the community and parents, which builds trust and boosts encouragement among educators, parents, and stakeholders in monitoring student learning and resource contributions.

On the other hand, the findings also indicate the need for improvement and further investment to ensure the sustainable development of SRSs in order to realize the vision and ambitions of the MoEYSand RGC for 2030 and 2050. Although the results have pointed out that facilities and teacher qualifications have significant connections with student performance, Cambodia is still struggling to provide and improve for SRSs and all other schools at all levels across the country. The strong effort and commitment of MoEYS and government to provide modern facilities and raise teacher qualification can account for gains in outcomes. The lack of school facilities and teacher qualifications are common issues that developing countries have been facing for decades (see Akey, 2006a; Kimani, Kara, & Njagi, 2013; Rockoff, 2004). While developing countries, including Cambodia, are trying to fortify their education systems with their available resources, they are also trying to catch up with evolving regional and global education trends. So, resource allocation has to be split between efforts to meet urgent needs specific to the country and long-term aims of the education and global development vision.

6. Implications

The findings of the present study provide a clear understanding of the strong connections between resource allocation and student performance at SRSs, over the time period of the last five years. This study has important implications for policy and practice. The results have revealed that school facilities and school teacher qualifications play a crucial role in determining student performance. Therefore, several implications are ca be considered. First, the continuation of constructing school buildings with a concrete structure and reducing the

number of schools with a wooden-structure is necessary. Each classroom shall be equipped with enough teaching and learning facilities needed for the different subjects in the school curriculum, especially science subjects which require a diversity of teaching and learning materials. Second, teacher upgrading, teacher training and professional development programs should be strengthened and encouraged. There are already various educator capacity-building and professional development programs) such as Teacher Upgrading Program (TUP) at the Royal University of Phnom Penh), teacher training programs, and scholarship for teachers. Schools should encourage teachers to pursue any opportunity for professional development in in order to increase benefits for themselves but also to impact student learning outcomes as a whole. Lastly, SRSs continue to expand and enhance the implementation of autonomy, accountability and assessment. This implementation has distinguished SRSs from other secondary schools for its effectiveness in provoking transparency and justice at school for better student learning outcomes. The findings of the current study provide a good indication of steps to take for the MoEYS to further strengthen and develop the system of schools and educators to improve their school's outcomes.

7. Conclusion

The current study has sought to contribute to the evaluation of the advancement and effectiveness of resource allocation to SRSs in Cambodia. It was found that among the 32 variables of the 4 constructs, several variables related to the infrastructure and human resource constructs were found to have significant positive and negative relationships with the variables for student performance. A decrease in schools with a wooden structure tended to have significant connections with increased student performance such as repetition rate, net enrollment rate at lower and upper secondary education, success of candidates in grade 9, and completion rates of both lower and upper secondary education. An increase in schools with a concrete structure had positive relationship with the number of students, net enrollment at the upper secondary level, success of candidates in grade 9 and completion rates at lower secondary schools. It had a negative correlation with repetition rate at upper secondary schools. At the same time, increased schools with a separate office had a positive correlation with net enrollment at lower secondary schools. Teachers with a lower secondary education had a significant positive correlation with the number of students, the repetition rate at lower secondary schools, the net enrollment at lower secondary schools, the net enrollment at upper secondary schools, and completion rates at upper secondary schools. Teachers with a lower

secondary education had negative connections with the repetition rate at upper secondary schools and the dropout rate at upper secondary schools. Teachers with upper secondary education were found to have a negative relationship with the number of students, the net enrollment at lower secondary schools, the net enrollment at upper secondary schools, the success of candidates in grade 9, the completion rate at lower secondary schools, and the completion rate at upper secondary schools. Also, it was found to have a negative relationship with the repetition rate upper secondary schools. Lastly, teachers with a post-graduate education were found to have positive correlations with the number of students, the net enrollment at upper secondary schools, the success of candidates in grade 9, and the completion rate at lower secondary schools. Having teachers with a post-graduate education was found to have a negative correlation with repetition rates upper secondary schools.

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Article

Study on Knowledge Attitude and Practice Tablet on Wheel for Teaching and Learning in Upper Secondary Resource Schools

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Abstract

Learning and Teaching entail an interactive process between three major factors: teachers, students and learning materials. These three factors are essential for the quality of learning and teaching at the level of secondary education. In early 2020, as part of the upper secondary school education sector development project supported by the Asian Development Bank, the Ministry of Education provided tablet computers on wheels to Upper Secondary Resource Schools and invited science teachers to attend a training course on the using of tablets and apps. This study will focus on four main points: 1) Measuring general knowledge of students and teachers related to learning by assistance from the information and telecommunication system 2) Measuring knowledge on curriculum utilization after participating in training conducted by the Department of Information and Technology of Ministry of Education. 3) Measuring the attitude of teachers and students related to using the App, such as the level of awareness of the value of App for learning and teaching; and 4) Measuring the use of tablets to impart the educational curriculum established by the Ministry. According to research findings, teachers in resource schools were not yet ready in teaching through app and Rachel (a piece of electronic devise to storge contents and share the contents to tablets or smart phone). There was some obstruction in teaching process including limited IT skills and the English language. Whereas Rachel, the majority of teachers think that Rachel is great for their teaching because they able to show students about concept more easily with usual explanations. It would likely be

premature to conclude that teachers and students do not find the use of Rachel or the App to satisfactorily improve pedagogy. In additional to initial instruction, teachers use it to better explain ideas. Besides teaching, teacher use it in demonstrate the lessons while student use it in verify their answers. On the other hand, teachers claim that the app was very easy to use because were able to they be able to use anytime and anywhere, even without the Internet.

Keywords: Tablet; study of science; internet; distance education; app

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1. Introduction

Learning and Teaching entail an interactive process between three major factors: teachers, students and learning materials. These three factors are inseparable when we talk about the quality of learning and teaching at the level of secondary education. Within the measurement framework of PISA (Program for International Student Assessment), it can be seen that there are many indicators that cover the above three factors, for example see, OECD (2010). Based on the necessity of these three factors, we observe that Cambodia has been strengthening and expanding these three factors simultaneously, especially in mandates of the last education strategic plans (MoEYS, 2019). In order to clarify whether or not the quality of education has changed, the balance of these three factors must be examined. However, given the scope of strengthening and expanding of the quality of teachers and students was too wide for a single investigation, this study focuses on the study materials, namely the effects of tablet utilization which is has been deployed by Ministry of Education as part of upper secondary school education sector development project (USESDP).

In the past, the Ministry of Education Youth and Sports has modernized in steps, including the equipping of school supplies, especially the establishment of resource schools including large buildings for STEM education and experimental equipment.

Recently, the Ministry of Education has also begun using in schools another modern device for the facilitation of science and math teaching and learning. The Tablet on Wheel (ToW) is a small tablet computer that can be taken from one classroom to another. The Tablets on Wheels

(ToW) program includes 30 tablets and a storage unit that can transmit data or lessons to the tablets on wheels via the WiFi network from Rachel. Each tablet includes many apps that contain the curriculum in different subjects and for many levels, especially the upper secondary level.

In early 2020, as part of upper secondary school education sector development supported by the Asian Development Bank, the Ministry of Education provided tablets on wheel to Upper Secondary Resource Schools and invited science teachers to attended training courses on tablets on wheels and app utilization by a trainer from Department of Information Technology and a national trainer by subject. After this capacity-building, these teachers of science and math would instruct their subjects using App in their classroom as needed.

1.1 Rationale

To advance and excel in technological progress and economic growth, each country competes across sectors, with the education sector at the forefront of the competition. Some countries have modified the curriculum and changed teaching methods by including the use of information technology in the curriculum. Some studies have shown that tablets improve reading skills, especially for slow learners (Berson, Berson, & McGlinn Manfra, 2012; Thoermer & Williams, 2012), and facilitate teaching (Berson et al., 2012). A pilot test in United State showed that it was effective in using the tablet in learning and teaching maths among many students because students could write a note on the tablets and the lessons in the tablets are colorful (Fister & McCarthy, 2008).

In the era of industry 4.0 and the expansive employment of information and communication technology (ICT), some studies looked at the use of technology to support learning for science subjects. According to experiments of Finkelstein, Adams, Keller, Perkins, and Wieman (2006) showed that the results of physics students were higher if tablets were used instead of traditional teaching. Doering, Koseoglu, Scharber, Henrickson claim that teaching and learning of science subjects were very effective when supported by information systems, and in particular it was more enjoyable for students, and Lanegran (2014) made similar claims for the subject of geography Shim et al. (2003), and Biology and Huang (2015) for Chemistry.

According to Hu and Garimella (2014) affirmed that knowledge of tablets from a training course enhanced STEM teachers' ability to instruct and evaluate their students. A detailed study of 33 research reports related to the use of tablets in the classroom by Major, Haßler, and Hennessy (2017) showed that tablet use generally correlates with better student performance.

While developed countries have succeeded in using information technology in education, the questions remain, at what stage is Cambodia in using ICT and how can we use it in education? At the time of drafting this research article, the internet system in Cambodia covered almost the entire country through mobile operators such as Cellcard or cable networks including EZECOM. By 2018, Cambodia has had 12 million registered Internet users. This number of internet users does not inform us of the details regarding user use, such as the reason for use, but it is known that some educators have created and enhanced lesson education for students through online learning, such as e-School Cambodia Or sangapac.com. Importantly the Ministry of Education has created apps and websites for learning and teaching including the MoEYS app Scan and http://www.krou.moeys.gov.kh/kh/.

1.2 Research questions and objectives

The research questions of this study are: To what extent the tablet can be used in teaching and learning in Cambodia? and how can tablet use be implemented successfully?

In this study, we will examine the knowledge, behavior, and practice of tablet utilization in teaching and learning at Resource Schools related to STEM subjects. This study will focus on four main issues: 1) Measuring knowledge on the general aspects of students and teachers related to learning with the assistance of information and telecommunication systems; 2) Measuring knowledge on curriculum utilization after training from the Department of Information and Technology of Ministry of Education; 3) Measuring the behavior of teachers and students in terms of app use or the level of awareness of the value of using the app for learning and teaching, and 4) Measuring the practice of Tablets on Wheels for the instruction of. In addition to those four dimensions, this study also examines challenges and opportunities by using SWOT1 analysis related to strengthening and expanding app usage, especially student self-study in cases of online teaching with Online learning Facilities.

2. Reviewing literature

Since the 1980s, information and communication technology (ICT) was included in the education sector of some developed countries such as Italy and the United States (Sharples,

1 A SWOT analysis is a compilation of the teaching-learning's strengths, weaknesses, opportunities and threats by using Tablets on Wheel (ToW). The primary objective of a SWOT analysis is to help the use of ToW develop a full awareness of all the factors contributing to materialize the USESDP outcomes.

Taylor, & Vavoula, 2010). The Figure below showed the evolution of ICT use in the classroom which can be divided into four major stages before the emergence of tablet technology. First, learning via voice, and through the use of radio, film, and slide projectors (Figure 1). Second, teaching through video in the form of TV videotapes, and the last two phases were the use of computers (especially laptops) for pedagogy and study.

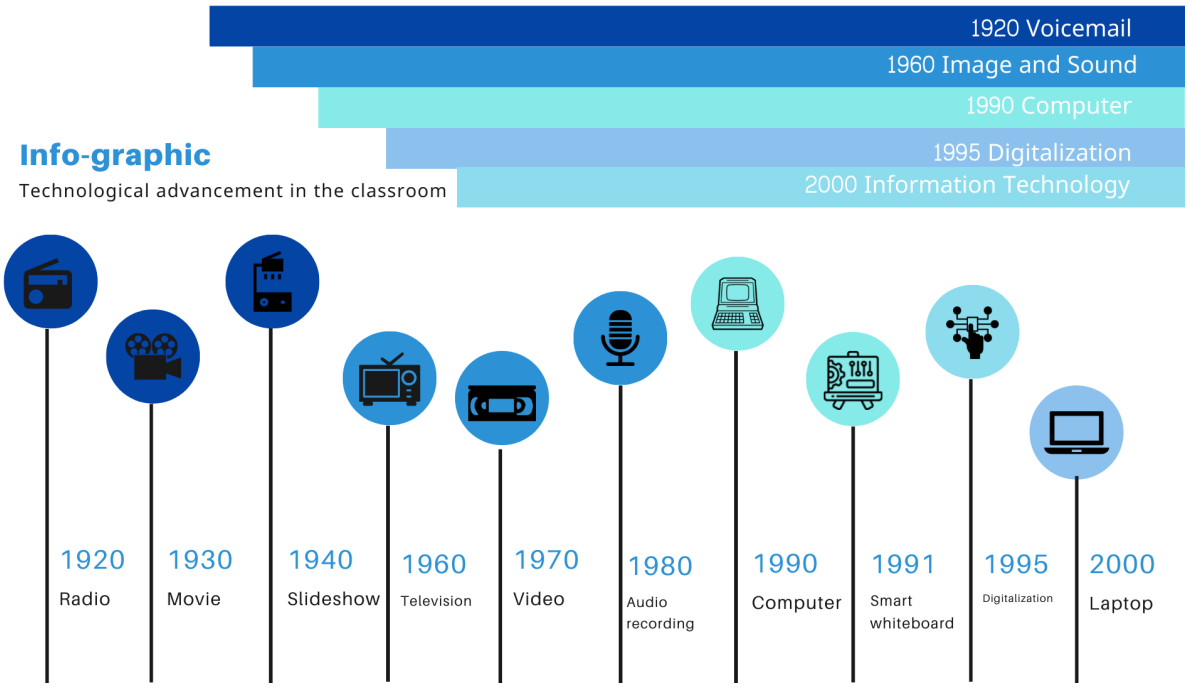

Figure 1: Timeline - Evolution of Technology in the Classroom

It is predicted that every student in the United States will have a tablet by 2020 (Norris & Soloway, 2015). The integration of technology in the education sector increased further following the introduction of tablet computers and widespread app availability with online services such as the Google Play Store and Apple Apps. According to a study by Clayton and Murphy (2016), the use of apps opens up freedom for students to gain more knowledge and build on what they have learned in the classroom, for example, Khan Academy. There are at least 1,000 free apps for education in the Apple Store (Watlington, 2011). In the USESDP, the Department of Information technology has assigned App in Maths, Physics, Chemistry, Biology and Earth Science are 9 App, 1 App, 4 Apps, 10 Apps, and 4 Apps, respectively in resource schools.

Because of the aid of tablets and apps for various subjects, today's classrooms are not the same as in the past, students are more able to seek knowledge on their own, with guidance from teachers. The study of Hagevik and Cherner (2016) on math and science teaching in rural

schools showed that current technology and learning with apps enable students to practice inquiry-based learning (IBL) and student learning outcomes are achieved specifically when the teacher integrates the Lesson Study Plan into an app.

3. Research methodology

This research study will use qualitative and quantitative data (students and teachers are scored by using the Likert Scale), open-ended questions, Yes/No questions, and qualitative data based on students' and teachers' perceptions on the use of tablets as well as online learning and teaching. We administered questionnaires at the resource schools and observed regular schools in the provinces and rural areas from May to August 2020. After analyzing the data and finalizing the draft research report, we invited the school principals and teacher trainers to disseminate the work to validate the research findings with the target beneficiaries.

After measuring the above four aspects and the scope of online learning of teachers and students, the study will provide conclusions regarding how to implement the project successfully. Furthermore, it will map out the way to provide educational services through online learning, especially during periods of school closure, such as in the case of a force majeure like in the case of the Covid-19 pandemic, or during vacation.

We asked students and teachers to complete the questionnaire to find out: 1) general knowledge related to learning with the help of ICT; 2) ability to use the app after the training from the Department of Information Technology of the Ministry of Education; 3) the attitude of teachers and students toward using the App in terms of the level of recognition of the value of using the App for learning and teaching, and 4) the practice of using the tablet for imparting the curriculum established by the Ministry of Education. Meanwhile, we invited teacher trainers and policymakers related to ICT systems to share their experiences and insights on strengthening and expanding learning with the assistance of tablet technology.

4. Research findings

The Resource Schools under the ADB-sponsored (loan) in the USESDP project received 30 tablets per school. The tablets are stored in a tablet on wheel that allows users to easily move the tablet from one room to another. The USESDP project also equipped schools with RACHEL-Plus and an LCD projector. RACHEL enables access to a full range of lesson materials in line with the Ministry's curriculum (with some materials written in some Khmer and some English). The files are contained in the same format as the general education website

and can be viewed without the need for an internet connection. Normally, 50 users can access RACHEL at a time, if necessary, IT experts divide up Intranet access for students to use on-demand throughout the school.

To access Rachel, users must have some basic knowledge of ICT, such as registering on a tablet and typing a web address (code) such as www.krou.moeys.gov.kh:8090 and www.krou.moeys.gov.kh:9090. Both addresses can only work if the tablet has a Wi-fi connection that broadcasts from Rachel (this piece of equipment acts as a home router). The officials from the Information Technology Department of the Ministry of Education have trained trainers (ToT) from 10 different resource schools.

The research findings are divided into five main areas: 1) the ICT capabilities of teachers and students; 2) knowledge of tablet use; 3) attitudes toward tablets; 4) practical usage of tablets; 5) the installation of tablets or other devices into teaching and learning during the Covid-19 pandemic.

4.1 Overview of the sample

There were 145 participants (48 teachers) from 9 provinces (a resource school in Kampot was selected to pilot the research tools) who have a resource school that received tablets (including the science teachers that received training on the use of those tools. Students from the ages of 15 to 22 years old and teachers from the ages of 24 to 50 years old were included in this study. Among all the respondents, more than 52% were female. All students are studying from 9th to 12th grade. Most of the teachers have a bachelor's degree and the highest level of education being a MA degree, held by 7 teachers. In Kratie and Tbong Khmum provinces, there are no students to answer the question because the students have not learned through the tablets yet. More than half of the respondents do not have email, especially students, while most teachers do. The number of people with strong English language abilities is about 20%, while another 20% have little or no English language skills. About 25% of the sample is computer literate, while another 30% can use MS Excel.

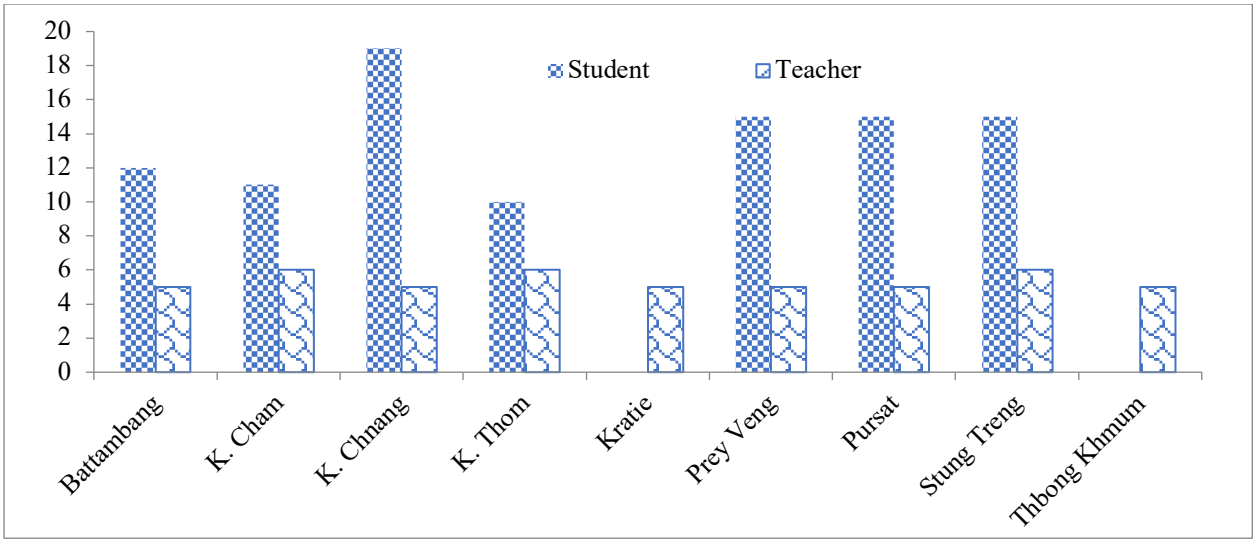

Figure 2: Respondents by Province

The total sample is in table 1. Some students and teachers were asked for separate interviews to get detailed answers to the questionnaire, such as "why were it that it was perceived as easy to learn through App but the student still wanted direct teaching from the teacher?" (Questions for students). For teachers, we asked, "why do you want other schools to gain the use of similar tablets?".

Table 1

Respondents to the Questionnaire

Type	**Female**	**Male**	**Total**
Teacher	17	31	48
Student	59	38	97
Total	76	68	145

4.2 Information about the tablet

Information and Communication Technologies, namely a desktop computer which was placed in a resource room in a school building. Following the completion of the EEQP project, the USESDP project also distributed about 30 tablets with resource schools in provinces across the country that are part of the Enhancing Education Quality Project (EEQP 2008-2014). In addition to tablets, a slide projector and Rachel were also equipped in each school.

To teach with tablets, the schools are required to equip with Rachel, tablets, and a slide projector. Apart from Rachel, various programs and apps such as Photo math or E-School Cambodia can also be installed on tablets. These Apps can be run independently from Rachel

and can also be installed on smartphones. Both Rachel and apps are new to students and teachers in Cambodia especially for those areas outside of Phnom Penh. Based on our observation students in Phnom Penh can access more apps than students in rural areas.

Schools that have been trained on how to use tablets have not yet implemented or taught students using these novel devices. Although some schools have already taught, it has been practiced only two or three times. Most of the tutorials are limited only to how to access and register on the device. Those responsible for teaching the use of the tablets in the schools are trainers (who also serve as math/science teachers at the schools in the program) who have been trained by the Ministry of Education, Youth, and Sports. Those teachers can manipulate tablets because they have moderate competency in English or their lessons are so simple to teach using the tablet.

4.3 Basic knowledge about ICT of the respondents selected as sample

In general, the capacity of teachers and students involved in ICT is limited. Most teachers and students do not have ICT equipment such as laptops, tablets, or good internet service. The good thing is that students and teachers all have smartphones. According to Table 2, we observed that teachers had more ICT devices than students at an index value of 2.35 versus 1.66. This figure means that most teachers have two devices (smartphone and laptop with WiFi at home), however, most students have only smartphones. The other figures confirm that teachers have better skills than students, especially for ICT or computer skills. For English competency, teachers and students have similar levels of English skills. Some secondary resource school principals claim that only children in the city can afford to buy ICT devices but the children in rural areas can hardly afford it or cannot afford it at all. The cost of internet service is also a challenge. Although some students and teachers have modern equipment, they have to remain close to the resource building to get internet access. On the other hand, students' English abilities are still very limited (especially the English language used in the lessons), making it difficult for students to use ICT to learn (according to some teachers).

It should also be noted that the smartphones that students and teachers have are not compatible with some applications especially students' smartphones with low storage. Students' ICT skills and practices show that students make little use of electronic devices. Teachers, students, and principals claim that the schools still lack these devices, especially tablets. By calculating the ratio between the number of tablets compared to the number of

students studying from grades 10 to 12 grade, it varies from high school to high school. The lowest tablets to student ratio are 1:26 (26 students have one tablet for Kratie Krong High School) and the highest is 1:74 (for Sihanoukville High School, Kampong Cham Province). There are three other provinces where more than 50 students have a tablet: Battambang, Pursat, and Kampong Chhnang. Because of this ratio, teachers and students claim that more tablets should be added to the schools to ensure that students use them more often.

Table 2

Average Score of Basic Knowledge of ICT of Respondents

Indicators	Teacher	Student	Total
Possessing equipment (max 5)	2.35	1.66	1.89
Level of English Competency (max 4)	2.1	2.02	2.05
ICT knowledge fluency (max 2)	1.42	0.89	1.07
Total	2.71	2.24	1.67*

* Note: Maximum value of ICT basic knowledge in this model is 3.66

4.4 Knowledge of Tablets

The knowledge in this study refers to the respondents' understanding of the benefits of and means for the use Apps and Rachel, such as what are the advantages of using Apps and Rachel, what are the requirements to use those tools, and where can Rachel and related apps be used. The measurement of this knowledge was based on three major indicators: 1) The number of Khmer apps (recommended by the Ministry and in the instruction manual of the Department of Information) that teachers and students use, such as Khmer Academy; 2) The number of lessons that can be used Rachel; 3) The number of people to whom that the respondents shared their knowledge of the app with.

In terms of the frequencies of the use of Tablet and App, figure 4 did not generally indicate any differences between teachers and students. Furthermore, more than half of the respondents did not use or had little use of the system installed at the resource high school. Failure to use the device is mainly due to the Covid-19 epidemic which led to the closure of the school after training.

Those who have used it in the past noted that the advantage of the app or Rachel is that it is open-source and available on mobile devices, which allows students to use it anytime and anywhere. Students can watch video lessons and repeat experimental processes on their own,

in addition, students can verify their homework answers with the app when they have finished any of the exercises. This enhances student independent learning and increases flexibility in current studies.

After the Covid-19 pandemic subsided sufficiently, following the direction of the RGC, the school reinitiated at the beginning of September, for 12th and 9th grades only, to prepare students for the final exams or BacII. The instruction is limited to the lessons on the subjects required for the examination. Tablet teaching was viewed by teachers as an additional demonstration to enhance students' understanding, and it was decided that time was too limited to utilize the technology for pedagogy at that time.

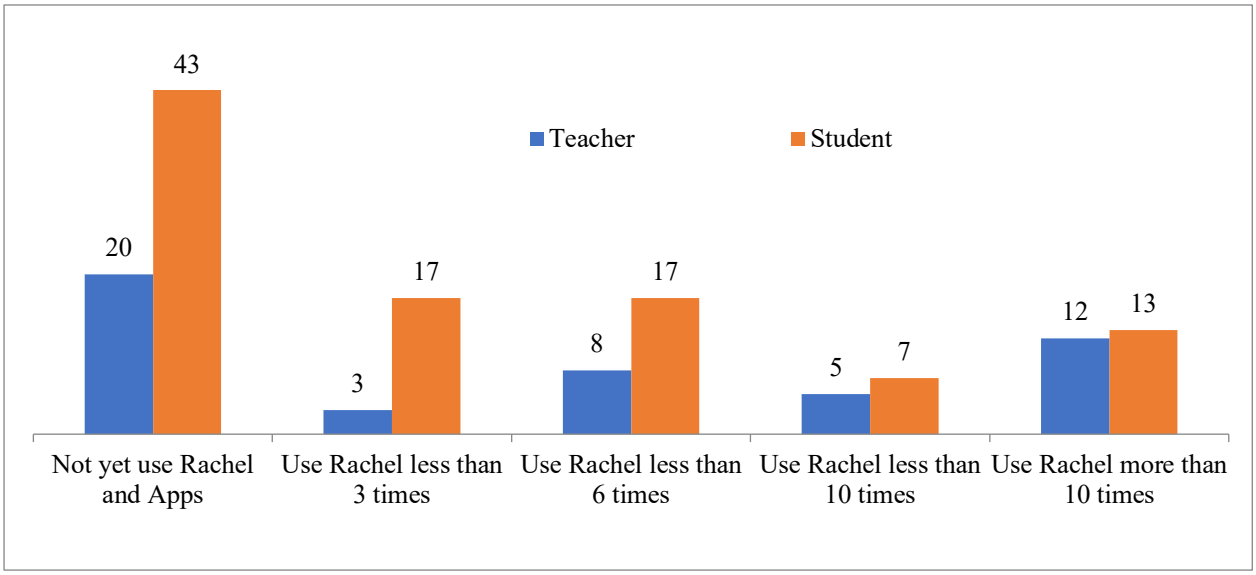

Figure 3: Lessons that Can Use Rachel for Learning and Teaching

Based on some respondents, they claimed that the app we have used in the past is very difficult to use because it is in English, we cannot understand how to best employ the app fully because of limitations in language abilities. Also, teachers indicated that adding more Khmer language material to the map is necessary to make it more accessible to students as well as increase their interest in the study.

The largest single challenge for learning with apps is the internet service, which is limited in rural areas, making it difficult to watch videos or download content with a high load. Sometimes devices could not run specific software. For example, when attempts were made to show the operation or solution of detailed equations, the phones would shut down, according to one teacher.

According to the researchers' observation, teachers with good English proficiency and medium computer skills (mostly young people) prefer to use ICT for teaching. However, for the older generation of teachers, the use of Rachel and apps in the Khmer language is necessary, along with more instructions on how to use them. In addition, it was found that there should be a more detailed handbook on the synchronization of lessons in Rachel and lessons in textbooks. Most students and teachers prefer e-School (See Figure 5, note that respondents could choose multiple answers) because this app is in Khmer and has lessons following the curriculum of the Ministry.

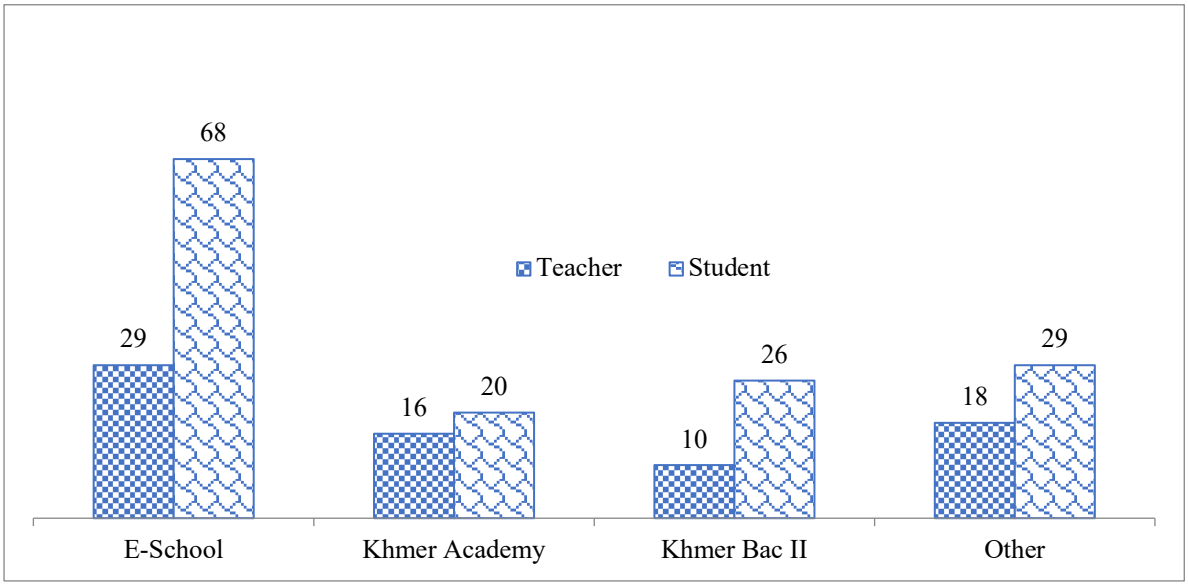

Figure 4: Apps Used by Students and Teachers for Learning or Teaching

It was also observed that all resource schools have trainers who can continue to train teachers in secondary resource high schools on how to use Rachel and teaching practices using apps and Rachel. But most of this training is done informally, that is, it is being taught from one teacher to another teacher and so on unless instructed to do so by the school principal. Figure 6 shows the percentage of people who shared knowledge among teachers and students. As the information in the Figure indicates, teachers and students want to share knowledge with others who have similar competencies. Utilizing a Chi-square test no statistical differences were found linked to gender or whether the sampled individual was a teacher or student.

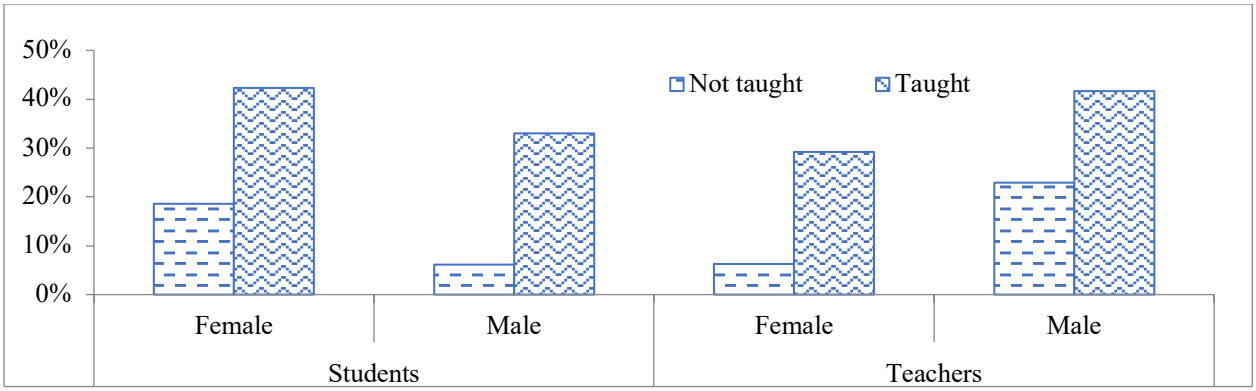

Figure 5: People Who Have Shared Their Knowledge of Tablet/App

Some teachers are still confused about the use of Rachel and Apps in tablets. Sometimes they think that Rachel is an app Also, they claim that the ministry should install more apps in Rachel so that they do not need to search for additional documents from other sources. However, teachers who have attended the training are more knowledgeable regarding the apps installed on the tablet. According to the survey, teachers have installed various apps into their mobile phones for further study. Even during the Covid-19 pandemic, some teachers advise students to use apps, especially in mathematics, such as PhotoMaths. This app makes it easy for both teachers and students to verify the answer. A student at one Resource High School claimed, "*I did a lot of homework because this app helps me do my homework and I can verify immediately without the need for a teacher to give answers*." At the time of this study, "*knowledge of the use of tablets among trainers is still difficult to estimate because we have just received new training*," according to one trainer. Tablet training for teachers took place shortly before Covid-19, and all schools have been closed but continue to teach with distance learning.

4.5 Attitudes on tablet use

The attitude towards tablets refers to the appreciation of or satisfaction with the apps and Rachel, such as how many downloaded apps are later put to use, the perception of the ease of teaching and learning using apps and Rachel compared to teaching without them, and whether or not the teachers or students have recommended that other teachers or students use these tools. According to Table 3, we find that more than 50% of respondents claim that Rachel and the apps are easy to use. However, most students answer that they do not like learning with apps, whereas most teachers were found to want to teach using the app. (The Chi-Square Test shows that $\chi 2$ (1, N = 145) = 16.178, p = 0.000). In terms of the recommendation of Rachel

and apps set to other schools and students, the students and teachers are not very different, but this data shows that students seem reluctant to recommend Rachel and apps set to other schools. The following is the qualitative data related to Table 3

Table 3
The number of respondents on use of app and Rachel

Question	Teachers		Students	
	Female	Male	Female	Male
Are the apps easy to use?	15	19	22	13
Are you satisfied with the use of the apps	13	17	6	4
Do you want other schools to have the Rachel and apps set?	17	26	37	27

Students who did not attend official Rachel and app training commented that Rachel helps learn faster, teaches concretely, and catch up on lessons quickly. One can find lessons without spending money like learning online, and it can be learned in conjunction with the support of a teacher. But at the same time, they view the tablet to have remaining shortcomings, such as Rachel remains less effective than blackboard instruction is more effective than Rachel, Rachel content in foreign languages is difficult to understand.

In particular, students who had been instructed using Rachel found that, for those students with sufficient English language knowledge, Rachel was are more effective than teaching using a blackboard. Rachel makes possible clear experimental study and makes it easier for students to independently take notes on the lessons. Moreover, Rachel facilitates learning science subjects. At the same time, some respondents found negative aspects of using Rachel, such as spending a lot of time setting Rachel up and turning on and off the tablet, which lead to wasted study time. Rachel often displayed programs or apps that were irrelevant to the lessons which resulted in distraction for the students' attention (advertisement on the flight). Additionally, more study time is needed when using Rachel for teaching. Rachel teaching requires more study time than teaching on a blackboard, and both study time and tablet access were limited

There are now apps in the Khmer language for all grade levels and all subjects. Fortunately, these apps do not need the internet to get access all the time, and they can work offline once the apps are installed on the tablet or the smartphone. In addition to the Ministry of Education's apps, distance learning services for all grade levels are provided through the website. It should also be noted that very few YouTube Channels, apps, and websites of MoEYS are included on Rachel. This reflects the policy choice to exclude publicly available content that has not been reviewed and verified by the Ministry to ensure quality standards are met.

As a result of the growth of ICT, during periods of school closure, it is possible to practice distance learning smoothly, especially where there is good internet access, due to the potential use of YouTube Channels, apps, and tutorials on the Facebook Page of the Ministry of Education. According to the survey, respondents held that there are no less than 100 YouTube Channels posted on the Internet, offering content appropriate to grades 1 to 12. Some public and private schools have produced content and posted it publicly, while others have posted videos online of their teachers giving lessons.

Overall, teachers and students have shown a very positive attitude towards tablets. Although teachers and students have not yet made full use of tablets on wheels, they recognize the essential utility of the ToW in the context of Covid-19. Some teachers and students purchased smartphones and installed apps similar to what is included with the tablets supporting schoolwork or for independent learning. According to some teachers and students, they have advised those who can afford it to use tablets or smartphones, because they can be used for daily operation and can be equipped for learning as well as assistance in teaching. One physics teacher claimed, "*With this app, I can easily teach and I can save half the time compared to traditional teaching*." Most science teachers were found to be satisfied with apps for teaching because apps make it easier to teach.

4.6 The practice of tablets

Measurement of Tablet performance refers to the use of the **app** and **Rachel** by students and teachers. Information was sought regarding the number of apps currently used, the number of hours they spent using them, and the necessity of the App or Rachel to design a lesson plan or for learning. We also learned about the challenges when teachers and students start using these apps. Table 4 shows that, following the onset of the Covid-19 pandemic and school closures, most of the teachers and students (57%) did not use the tablet set after the training. However, some teachers with more capacity, such as trainers, have been using the tools.

Table 4
Tablet Set Use in the Classroom

	Not used yet	Rarely	Medium	Often	Very often
Students	22	35	36	3	
Teachers	15	9	19	3	1
Total	37	44	55	6	1

Some physics teachers asserted that some lessons took six hours to teach, but using Rachel can save about three hours without compromising the quality of teaching. They also opined those students prefer the more modern teaching method since they can do any experiment and rotate 3D images. Seeing the benefits of Rachel, one teacher wanted to download lessons from Rachel to the mobile phone, but it was not possible yet.

Some science teachers asserted that Rachel contains about 50 percent of the lessons following the curriculum, which saves about 30 percent of their time if they taught by using Rachel because students can understand the lesson faster than when the teacher using traditional practices of instruction. One teacher found Rachel to be a good complement to his teaching process, especially in the third step. They also claimed that the number of tablets was still very low if all students had to learn using tablets.

However, such assertions seemingly contradict student claims that learning by tablet was very difficult because it took a lot of time to operate it. Their assertions may partly reflect limited experience in using the app and Rachel. Empirical findings show that a limited understanding of English was the main barrier to use. The barriers respondents face are the barriers that respondents asserted (Table 5).

Table 5
Reported Barriers Encountered by Users

Barriers to learning or teaching with the tablet set	**Teachers**	**Students**	**Total**
Do not know where to find the relevant lessons	18	24	42
Student lack of English knowledge	30	46	76
Difficulty connecting the tablet to slide projector	14	18	32
Too little study time	30	45	75
Unable to prepare lesson due to the Rachel is at school	21	38	59
Some parts are locked, unusable (must be purchased)	22	49	71

Note: The sample size for this question was 124 (the question was not asked in Kampong Chhnang)

Table 5 shows that students' insufficient knowledge of English (76 out of 124 respondents) of them said English is a Barrier) and too little study time were the main barriers to learning or teaching with tablets. Both teachers and students asserted that English proficiency is the main factor in smooth learning and teaching. The Chi-Square test between the variables in Table 5 (including the gender of the respondents) did not indicate differences between teachers and

students or between males and females, supporting the conclusion that this problem was common among respondents.

According to some students, what would be most helpful is an app that comes directly from the Ministry of Education, Youth and Sport for the 12th-grade exam, which allows them to study independently despite the closure of the school. Some indicated that they do not have confidence in the apps released by teachers or other companies yet, even if the apps are in Khmer. Additionally, respondents indicated the view that the app used in schools must be following the Ministry's curriculum to strengthen the quality of learning and teaching. Table 6, in addition to the above barriers, we need to ensure that the app is in Khmer, with extra study time and more tablets.

Table 6
Report of responses on app improvement

Tablet Set	Teachers	Students	Total
App is in Khmer	41	77	118
Extra study time	30	52	82
Add more tablets	32	47	79

Note: The sample size that answered this question was 124 (these questions were not asked in Kampong Chhnang)

Based on the survey, regarding the knowledge of tablet use and the behavior and practice of those sampled, we can generally say that the practice of teachers is delayed only by the pandemic-related school closure.

The first indication that it will be widely used among teachers and students is that the modern teaching techniques provided clear instruction regarding concepts to students using video-based learning via Rachel. According to a female student, "*Studying like this makes me very interested and I am more eager to study medicine because it makes me more confident*". One teacher claimed that he wants to teach using the app, but has not yet had the opportunity.

Some teachers and students insisted that the number of tablets was insufficient for students and teachers to practice. Some principals the improvement in the quality of learning offered by the app may be limited because of restrictions on study time, with students able to access the computer room only two times per year.

4.7 Digital Education Opportunities

The study also explores the distance learning that teachers and students at secondary resource schools have conducted during the Covid-19 pandemic. The aim was to investigate questions related to the use of internet service, ICT by teachers and students so on.

Most school principals asserted that tablets are valuable for teaching students about experimental lessons, as they allow students to see the real experimental activities. Formerly, learning and teaching were very abstract. Thus, having a tablet makes students interested in learning, and makes it easier to observe and understand practical aspects of the study. For example, chemical reactions are usually difficult to perform directly due to a lack of materials and the danger involved. Teaching via the app, especially using Rachel, enables students to understand the concept of chemical reactions by watching experimental videos. If possible, then the teacher could directly repeat the experiment. Moreover, some experimental processes, especially in Biology, take a lot of time and money, and so Rachel can help a lot in terms of time and expense. Learning by the textbook alone makes lessons less interesting and able to keep the attention of students. But via the app, students can see 3D pictures, which makes lessons more interesting, and ultimately enables more confidence in students.

This study shows that learning and teaching using ICT through App and Rachel is still limited, but many students and teachers are also more aware of ICT, which means it is a good time to integrate ICT into learning and teaching (as shown in Table 7). ICT is used in the daily lives of students and teachers which means that the use of ICT in pedagogy means the education sector is being updated as well.

Table 7

SWOT Analysis Table on Tablet Use

Internal factors	**Strengths**	**Weaknesses**
	1. Teachers and students can use the tablet at all times 2. Tablet teaching schedule required 3. Organised training course on the use of tablets	1. Few IT teachers 2. More tablets needed 3. Tablet maintenance (update software)
External	**Opportunities**	**Threats**
	1. App learning or distance learning is popular 2. Almost all students have a smartphone	1. App in English

3. Improve English and ICT skills	2. App does not match the lessons of the Ministry of Education, Youth and Sport 3. At home, students and teachers cannot use Rachel

Generally, studies show that students are more interested in learning when ICT is used, namely, smartphones and tablets with responsive apps or dynamic apps. This study also found that students enjoyed learning from apps and Rachel, especially in math and science.

Indeed, the ICT is still in the early stages for developing countries such as Cambodia. Moreover, at all levels, there are no teaching methods for teaching by using ICT, even in pedagogical schools.

There was a lot of discussion about apps used on smartphones and tablets. There are usually available apps for education, but it is not certain that such apps are effective for teachers and students. Some Apps are no different from e-books or YouTube. To increase the effectiveness of an app, the Ministry of Education, Youth and Sport have to evaluate integrating it into the curriculum. Previously, the Ministry did not have the policy to manage and evaluate these apps.

In general, training on the use of tablets is necessary for the schools to run even in the context of Covid-19 because teachers and students have the basic knowledge to use the apps. Some secondary resource school principals asserted that we know in advance that there is a need for distance learning and that we have tablets with apps for learning, so it is essential to have new capacities such as using Zoom or Google Meey. Importantly, some teachers also understand that this is a step towards achieving a digital education.

5. Conclusions

The research findings are divided into five main areas: 1) the ICT capabilities of teachers and students; 2) knowledge of the use of tablets; 3) attitudes towards tablets; 4) the practice of tablets, and 5) integration of tablets or other devices in learning and teaching during the Covid-19 pandemic.

In general, the capacity of teachers and students involved in ICT is limited. Most teachers and students do not have ICT devices such as smartphones, tablets, or good internet service.

Some school principals asserted that "only urban children are capable but children in rural areas children find access difficult". The cost of internet service is also a challenge. Although some students and teachers have a modern devices, they also come to access the internet at the resource building. On the other hand, the English language proficiency of students is insufficient, which makes ICT learning difficult.

"Knowledge of the use of tablets among trainers is still difficult because we have just received new training," said one trainer. The training on the use of the tablets took place shortly before the Covid-19 pandemic, and all schools closed in began to operate through distance learning. However, teachers who have attended the training are more aware of the apps installed on the tablet. According to the survey, teachers have installed apps on their smartphones for further study. Even during Covid-19, some teachers introduced students to using apps, especially for mathematics, such as PhotoMaths. Apps make it is easy for both teachers and students to verify the answers. A student at secondary resource school asserted, "I did a lot of homework due to the help of this app; I can verify the answers without the teacher having to make the solution."

Teachers and students have shown a very positive attitude towards tablets. Although teachers and students have not used them extensively due to the Covid-19 pandemic, there are trends that the device is necessary for improving education. Already, some students and teachers have bought smartphones for installing apps to support learning and teaching, especially for independent learning. According to some respondents, they have advised others who can afford it to use tablets or smartphones, because they can be used daily and can be installed with apps for learning as well as for teaching. One physics teacher asserted, "With this app, it is very easy to teach and I can save half the time compared to regular teaching". Most science teachers like to use apps for teaching because they enable practical demonstrations and observable experimentation.

The practice use of teachers and students with tablets is just waiting for the time when schools are no longer closed as a result of the pandemic. The first indication that it will be widely used among teachers and students was observed when teachers and students gained an understanding by watching the video via Rachel. According to a female student, "Studying like this makes me very interested and I am more eager to study medicine because it makes me more confident". One teacher claimed that he wants to teach using the app, but has not yet had the opportunity. Some teachers and students insisted that the number of tablets is insufficient

and that schools should have more to enable students and teachers to practice more often. Some principals said that it is difficult to say that this tablet will greatly improve the quality of learning and teaching because of too little study time per year, given that a student can enter the computer room at most twice a year.

In general, training on the use of tablets is necessary for the schools to run even in the context of Covid-19 because teachers and students have the basic knowledge to use the apps. Some secondary resource school principals asserted that we know in advance that there is a need for distance learning and that we have tablets with apps for learning, so it is essential to have new capacities such as using Zoom or Google. Importantly, some teachers also understand that this is a step towards achieving a digital education.

6. Recommendations

Ministry of Education: Students and teachers argued that there is too little time to access tablets, and they can only use them in the resource room. If possible, students and teachers should have Rachel in their respective classrooms, which would allow for use anytime during lessons.

There are a lot of free apps and videos for education available online. If the Ministry of Education can review and upload apps and videos to Rachel, it will greatly enhance the learning and teaching materials available and improve user experience.

If possible, the ministry of education should translate the English contents in Rachel into Khmer, as teachers and students in rural areas do not yet have extensive language skills. It is noted that the documents in Rachel are in both Khmer and English, but the documents in English are more attractive with better quality.

Teaching using ICT is not yet widespread, so the Ministry of education should add ICT or embed ICT into all subjects at the general education level, and into professional development at pedagogical schools at all levels. In addition, the curriculum should include ICT, so all teachers must teach by using the ICT. Teachers and principals now understand that teaching by using ICT are optional.

ICT training is still lacking, especially for teachers ages 45 and over who are reluctant to use ICT for teaching, as they do not seem to trust the system. Therefore, to be widely used,

ICT training should be conducted as much as possible among general teachers. In addition, the Ministry of Education should publish a guidebook on the use of tablets to support teaching and learning, or, if possible, should include these activities in the Ministry's textbooks.

Teachers: Should improve ICT and English skills because it will help to enhance learning and teaching, as the documents in Rachel are mostly in English, and of good quality compared to locally produced documents.

Teachers of all subjects at the secondary resource school should be trained as trainers, and they will become trainers at their school, the network schools, and the cluster schools. If possible, these trainers should be subsidized for this extra work as an incentive to strengthen and expand ICT for teaching and learning.

Previously, teachers in each subject relied on IT teachers to use the tablet set-up in the resource room, and if the IT teacher was not there, it was very difficult to operate the tablet. Therefore, we should have a guidebook on the use of tablets for teachers and students. All teachers and students should be able to use these tools independently, with this guidebook.

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Ministry of Education, Youth and Sport
Department of Policy

Article

Lessons Learned and Best Practices of the Implementation of School-Based Management (SBM) in Cambodia

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Abstract

The application of school-based management (SBM) is considered a core activity of school reform in order to improve performance and effective education service delivery. SBM is a new mechanism that school becomes property of the local community, and it will be a new journey in bolstering Ministry of Education Youth and Sports or MoEYS' efforts to strengthen the ability in human resources management and results-based planning, budgeting, and execution under the direct supervision of community participation at school level. Enhancing autonomy and transferring responsibility to the school level through encouraging responsiveness to local needs has become a new policy priority for improving schools, and teacher capacities, and family involvement. The study uses a quantitative approach, and the school samples are randomly selected from eight provinces for data collection. The current status of the SBM's implementation has been examined, including: school leadership and management, budget management, curriculum and instruction, resources management, staff management. According to the data, the current implementation of SBM in schools is basically on the right track because school directors, teachers, and members of the school management committee closely work together to develop the school capacities and foster education outcomes. It is a positive sign of growth to continue to expand and strengthen the SBM platform in Cambodia's education system. The results of this study on SBM can inform current practices and also contribute tofuture SBM policy interventions and their application in practice.

Keywords: School-based management, school management committee, autonomy, decentralization, community participation

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1. Introduction

School-based management (SBM) reform is seen as a promising strategy to improve education quality by empowering decision-making closer to local communities and strengthening accountability between the schools and the parents and children. SBM reform empowers school directors and teachers and augments their professional motivation, thereby enhancing their sense of ownership of the school; SBM is used to decentralize authority from the central government to the school level (Caldwell, 2005). The principles of the school-based management framework include 'decentralization', 'participatory school leadership and management, 'staff capacity development', 'self-management, and 'monitoring and evaluation' (Lunenburg & Ornstein, 2011; Cheong & Mo, 2007). Through SBM, decision-making is decentralized to districts and schools to develop inclusive policymaking and participatory administration. SBM is a logical process where teachers are able to take part in decisionmaking, restructuring, and site-based management (Goldman et al. 1993).

Globally, the application of SBM has been widely implemented as a means of decentralization for school reform (Ai Shoraku, 2016); the system helps leaders manage their school more transparently and less corrupt, as well as provides opportunities to parents and stakeholders to increase the scope and quality of their involvement. The effective organization of training in shared decision-making, interpersonal skills, and management skills for school council members make them more capable through participating in the SBM process and, at the same time, benefit the community as a whole (Briggs & Wohlstetter, 1999). For example, a study report in the Philippines found that there is a better improvement of learning performance after school undertakes school-based management. As a result, students who participated in SBM-applied schools had a higher mark than those in non-SBM schools (Nidhi Khattri et al., 2012). A formation of the school management committee comprising of

directors, teachers, parents, and local authorities has provided solid support to manage their local schools in line with national policies and fulfill the right needs of its local context.

To increase the participation and impact of all stakeholders (such as school management committee members, teachers, and school board) in prioritizing effective program monitoring and evaluation in the school, since 2001, the Ministry of Education, Youth and Sport (MoEYS) has introduced the concept of decentralization in its strategic education plan (2001-2005). SBM was a part of the decentralization process by which MoEYS has allowed for autonomy of leadership and management, and decision-making regarding school development and student learning achievements, at the grassroots level (districts, community, and schools) [MoEYS, 2018]. SBM is an enabling mechanism for improved use of local resources through restructuring school governance grounded on the stronger engagement of the communities. It is, therefore, important that SBM is designed with the goal of systematic education reform (Blank, 2004, Conley, 1993).

More recently, MoEYS has carried out a comprehensive educational reform aiming to increase the number of youth and adults with strong literacy, numeracy, and soft skills integrated with technical and vocational skills, to reach the goal of increasing employment and entrepreneurship. The in-depth educational reform has primarily set out four primary components for school-based management (SBM): administration and general management, teaching-learning management, financial management, and personnel management (Hang Chuon, 2017). School principals in schools that are implementing SBM should have a good knowledge of financial management in order to use it effectively for operational programs. It is envisioned that when SBM is applied to schools, the mechanism of budget transfer for operations be transformed, as stated by the minister of education, "Financing reform may also include a transfer of budgetary resources directly from the National Treasury to schools or to improve financial procedures and governance to require better learning outcomes," (Hang-Chuon, 2016).

MoEYS has decided to pilot the current SBM program in a more comprehensive way than the previous SBM initiatives at secondary schools under the Secondary Education Improving Project (SEIP). The previous school-based programs are not obsolete but co-exist with the new piloting program. One hundred lower secondary high schools have been selected to implement the SBM program with technical and financial support from World Bank and the central MoEYS assistance teams, and it is expected that the program will expand from 100 to 500 schools across all levels by 2023. The "School-based management" system was officially approved to introduced to the school leadership and management by MoEYS on 12 September

2018. The object of this study is to examine the current implementation status of SBM activities in schools (participation, and transparency, capacity, and support provided by the relevant agents for the implementation of SBM). The results serve to inform preliminary policy strategies to optimize implementation of SBM.

2. Research methodology

In order to ensure an informed and comprehensive understanding of the current SBM implementation status in Cambodia at the school level, the researchers used a qualitative method. To ensure the current practices of SBM school and future direction of SBM, the questionaires are designed into two main parts: the current practice and the perspectives of SBM at school base in the future by rating the scale from 1 (strongly disagree) to 5 (strongly agree). The research instruments designed were structured questionnaires separated into three sample categories. The first category was targeted to school director, the second was targeted to teachers, and the last one was targeted to the school management committee. After completing the questionnaire, the research team has requested the school directors and colleagues to provide time for an interview in order to find increase the scope of information collected to better support data analysis and interpretation. The research mainly investigated the SBM practice at school from year 2018 to 2019, meanwhile, it overviewed the practice of other countries in latest literature reviews.

For the sample, 235 secondary schools (school director, teacher, and school management committee) including SBM and its network schools in twelve provinces were randomly selected by lucky draw from the list of target provinces: Battambong, Kampot, Kampong Cham, Koh Kong, Mondulkiri, Kampong Chhnang, Steung Treng, Prey Veng, Kampong Speu, Pailin, Preah Vihear, and Takeo.

3. Results and discussions

3.1. School leadership and management

According to the interviews, an overwhelming number of school directors agreed that one of the prominent strategies to currently execute SBM was through a professional training and degree upgrading mechanism for school principals and teachers. All SBM schools have required teachers at least have a bachelor's degree. To evaluate the level of SBM in context of individual schools, several parameters have been generated to assess practices in schools, including sufficient autonomy in leadership, collaboration in the working environment, the

capacity for monitoring and evaluation, authority in the decision-making of staff recruitment, an ability to build a community network.

The **Figure 1** showed that a majority of school principals, corresponding to 82.4%, agree that they have sufficient autonomy to lead the practices to improve the school, implying that schools in the present context are autonomous in self-management and leadership in their school. Notably, the number of respondents who expect increased autonomy in the future went up from 7.8% to 52.9%. The increasing number was also inferred that there are some remaining barriers that they still cannot enforce their full rights and authority in self-governance. Based on the respondents, it could concluded that although school principals have adequate autonomy in the present, they strongly expect to gain more autonomy in the future.

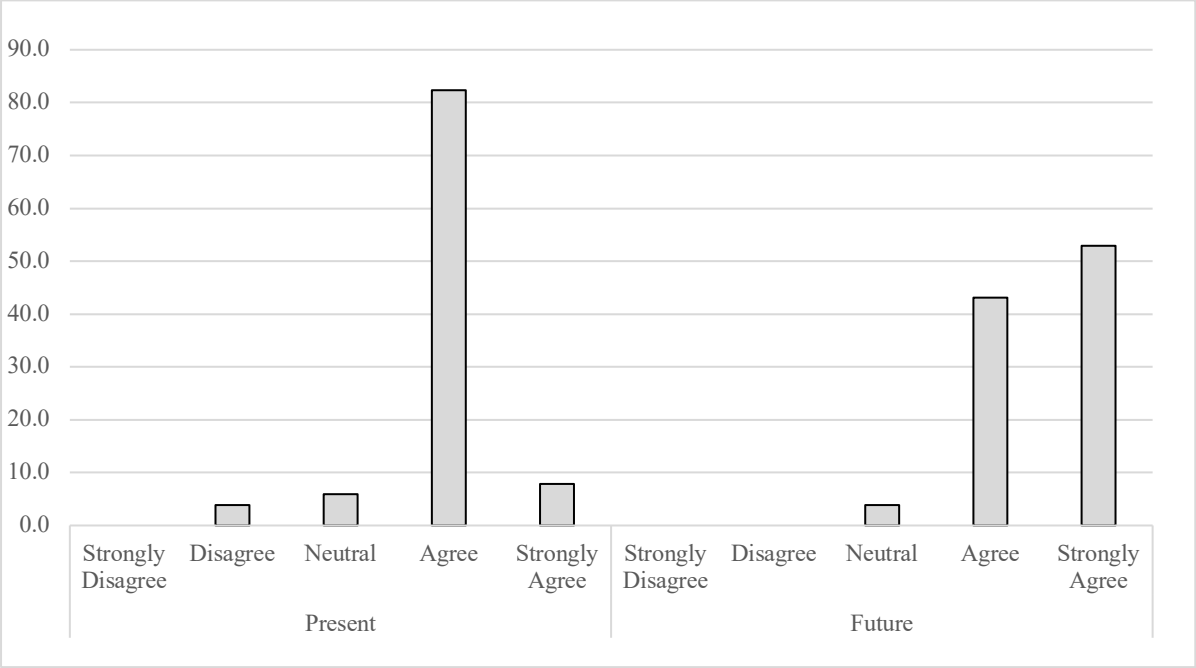


Figure 1: Majority of school directors have sufficient autonomy to lead the practices most likely to improve student learning at present and wish to gain more autonomy in their role in the future

The research showed that, although there are some differing opinions, , the majority of school directors are encouraged and supported in building a collaborative environment for teachers and the surrounding community (**Figure 2**). These indicate views consistent with SBM guidelines encouraging school directors to build a good network with both internal and external stakeholders. In this sense, most of the school principals understand the importance of stakeholders and their positive impact on school development and shared responsibility. As shown in **Figure 2,** that at present a small number do not perceive that they have access to the

support needed for building collaborative cultures. However, they do desire that it is be more available in the future. Additionally, they strongly agree on the importance of building collaborative cultures among teachers and stakeholders in school, as the number of respondents indicating agreement or strong agreement is about 25% (for the present) while it is approximately 55% (for the future). All in all, most of the school principals perceive they have support and encouragement for building collaboration and networking with the community.

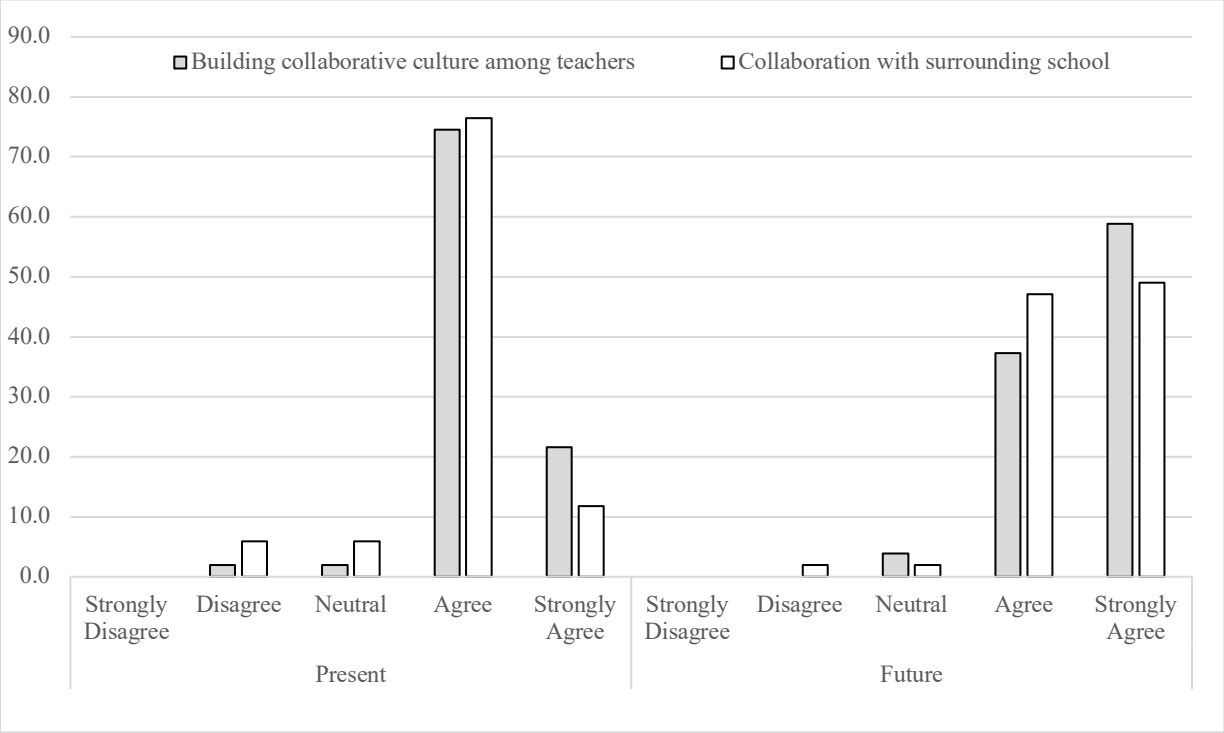


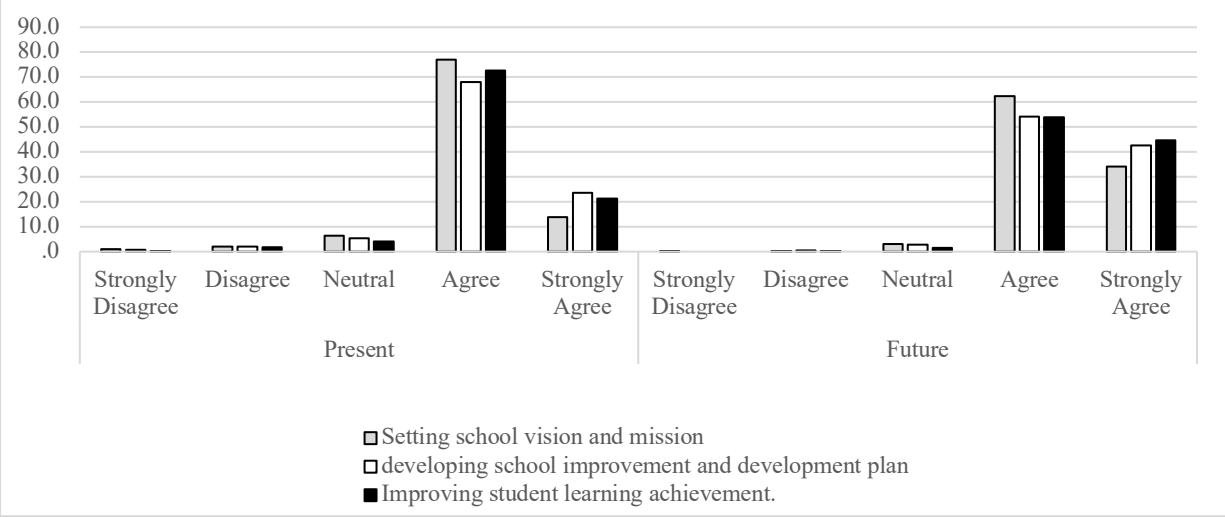
Figure 2: School directors are encouraged and supported in building collaborative cultures among teachers and to collaborate with surrounding schools.

Similarly, teachers were observed to perceive that they are actively involved in shared responsibility with school principals for setting school vision and mission, developing school improvement plans, and for improving student learning achievements. As indicated by the data, around 90% of the total numbers of teachers agree and strongly agree that at present they hold shared responsibility, implying that in practice the effective leadership of the school is not the sole responsibility of school directors, and both teachers and community members are also share a part of the responsibility as well. Moreover, teachers and school management committee (SMC) members expect to be more involved in these responsibilities in the future, with those in strong agreement or agreement regarding shared respponsiblity in the future increased from approximately 20% to 40%, and 22% to 50%, respectively (Figure 3A).

The high number of school principals have participated in setting the school vision for learning outcomes and in drafting school plans, indicates that school principals see that active participation in indispensable for plotting the course forthe school educational program activities and school development plans. However, a certain number of respondents still point out that they had not been involved in setting out school mission and plans. Meanwhile, there are some respondents that indicated that they were not certain whether they should participate. In spite of the small number of these case, it could become a bottleneck in SBM implementation in the future if the relevant parties are not included in this matter. Actually, they are willing to participate if a desirable mechanism is established. As noted, the data indicates that an increasing number of school principals desire to be participated in setting vision and planning (Figure 3A).

Additionally, as Figure 3B shows, a majority of respondents have been involved in school improvement activities, in developing school policies, in the decision-making process on school financial resource management, in teacher professional development, in the evaluation of school director performance at present. Moreover, their enthusiasm for participation is evident on the basis of the increase in the number of strongly agreed respondents was double from the present, proving that they see the importance role of participation in these programs. Unfortunately, a small number of teachers were not able to participate or were unsure whether or not they were allowed to take part such activities, while at the same time did not indicate a willingness to be involved in the future (Figure 3B). As such, in those schools there is a substantialchallenge to implementing school-based management, since it requires teachers get involved in school related program activities.

(A)



(B)

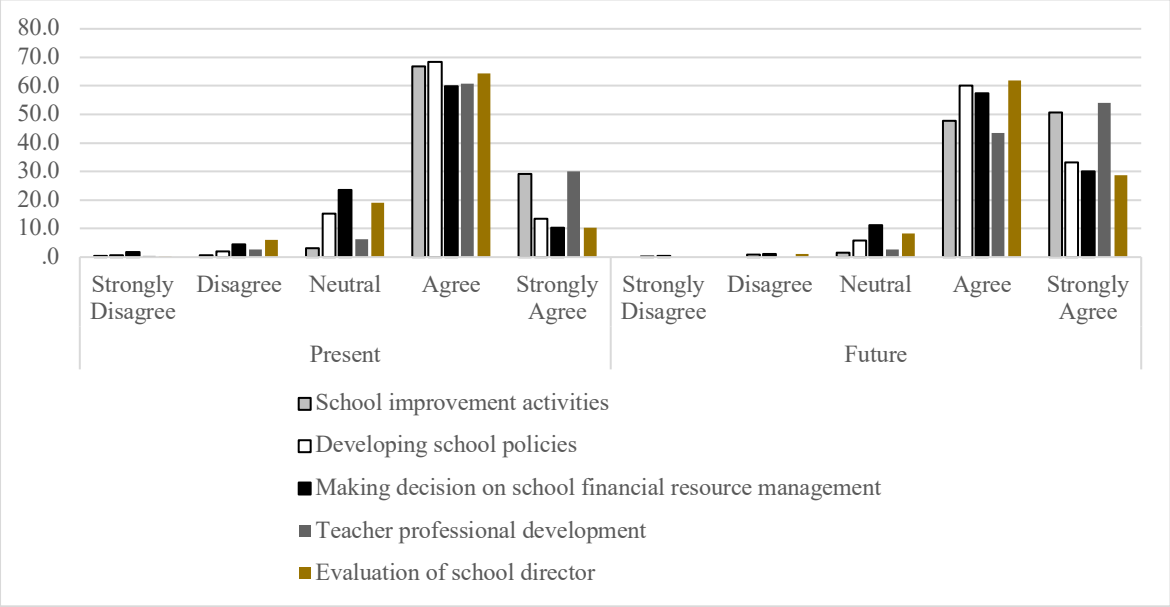


Figure 3: **(A)** Teacher shares responsibility with the school director in setting school vision and missions, designing school improvement and development plans as well, and in setting goals for student learning outcome, **(B)** Teacher is involved in school improvement activities, in developing school policies, in decision-making processes related to management of school financial resources, in teacher professional development, and in the evaluation of school director's performance.

3.2. Budget management

Financial management is one of the main components of education reform. In this view, school principals who have knowledge in the financial sector would be benefical toSBM. Moreover, principals with insufficient knowledge would need to improve this financial management skills in order to accord with the SBM program standards and best practices. According to the interview, the school principals mentioned that their school lacked human resources in this skill and had made a request to recruit the contract staff whose skills are matched with the local school needs. As indicated in **Figure 4,** most of the school principals are involved in preparing the annual school budget and allocating resources based on the needs of the school, while only a few of them do not participate in preparation and allocation. The data confirmed that they are willing to be more involved in the preparation and allocation of budget in the future as the number of respondents who strongly agree on the perception of future involvement was double the figure for those who perceived to be involved in the present.

Based on this point of view, the conditions for the operation and effectiveness of SBM in Cambodia is most likely attainable given that an overwhelming number of principals are willing to play a key role in budget preparation and allocation, despite the small number of respondents who do not show a desire to get involved in this matter in the future.

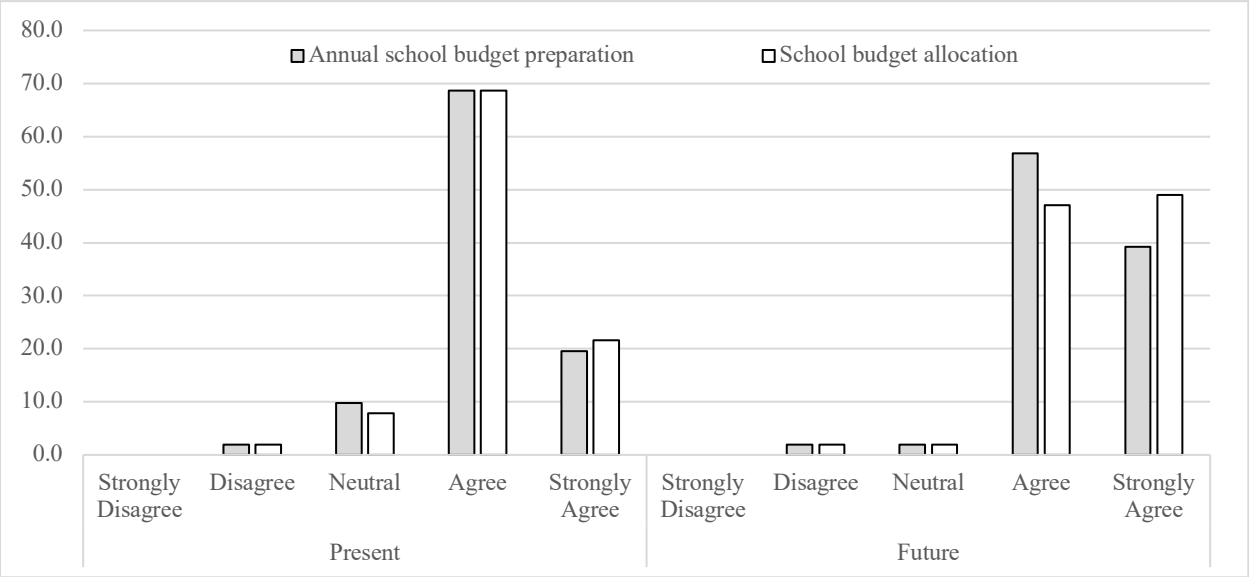


Figure 4: School director prepares the annual school budget and allocates school budget resources based on the needs of the school.

Moreover, there is a range of various responses regarding procurement in the present school context. As indicated, the degree of school principals that strongly agree, agree, neutral, disagree, and strongly disagree is around 12%, 50%, 25%, 10%, 3%, respectively. This shows that over half numbers of the schools surveyed have conducted a procurement. Meanwhile, a moderate number of schools are not clear whether they are authorized to do so. In turn, around 10% of the total schools have never carried out a procurement at their school. The number of respondents that strongly agree that budget prep and allocation occur stands at nearly four times the figure for the present, confirming that the principals strongly expect to conduct the procurement a the requisite autonomy is maintained.

Based on the statistical data (**Figure 5**), plenty of respondents agree and strongly agree with the idea of the participation of teachers and school management committees in budget planning, execution, and clearance. The research confirmed that a lot of schools have already established a framework with three pillars (school director, teacher, and school management committee) for decisionmaking for budget planning, execution, and clearance. The involvement of school principals, teachers, and school management committee in school budgeting will create a more transparent and accountable environment in schools, which is consistent with the activities and

outcomes of SBM programming. Interestingly, an increasing number of principals strongly agree on the idea of the necessity of involvement of these three types of actors in school budget management in the future.

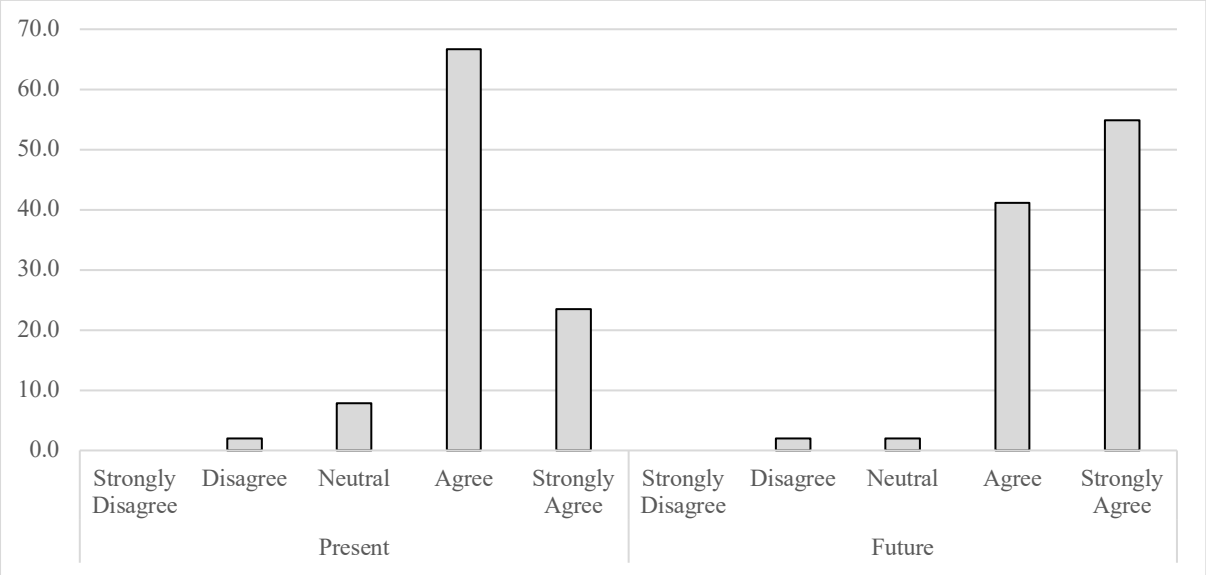


Figure 5: School director has involved teachers and the school management committee in budget planning, execution, and clearance

Regarding school budget management, around 60 percent of respondents agree that teachers should be involved in the preparation of the annual school budget, in the allocation of school budget resources based on the prioritized needs, in school-based procurement, in budget clearance. At the same tiem around 10 percent of the respondents have not been involved and nearly 30 percent are uncertain whether or not they are permitted to be involve in budget management (**Figure 6**). The results also correspond with **Figure 5**, which illustrates the extent that school directors have involved teachers in school budget management. Moreover, increasing the number of respondents that are willing to get involved in school budget management in the future is greater. This tendency is good for school-based management implementation. For the school management committees, around 60 percent of respondents saying that they have been involved in school budget management, including drafting theannual school budget, allocating school budget resources based on the actual needs, using school budget resources efficiently, and doing budget clearance. They are willing to get more involved in the future as the number of respondents indicating agreement reached about 85%. Therefore, if the school provides them more spaces to participate in budget program budget, they will respond enthusiastically

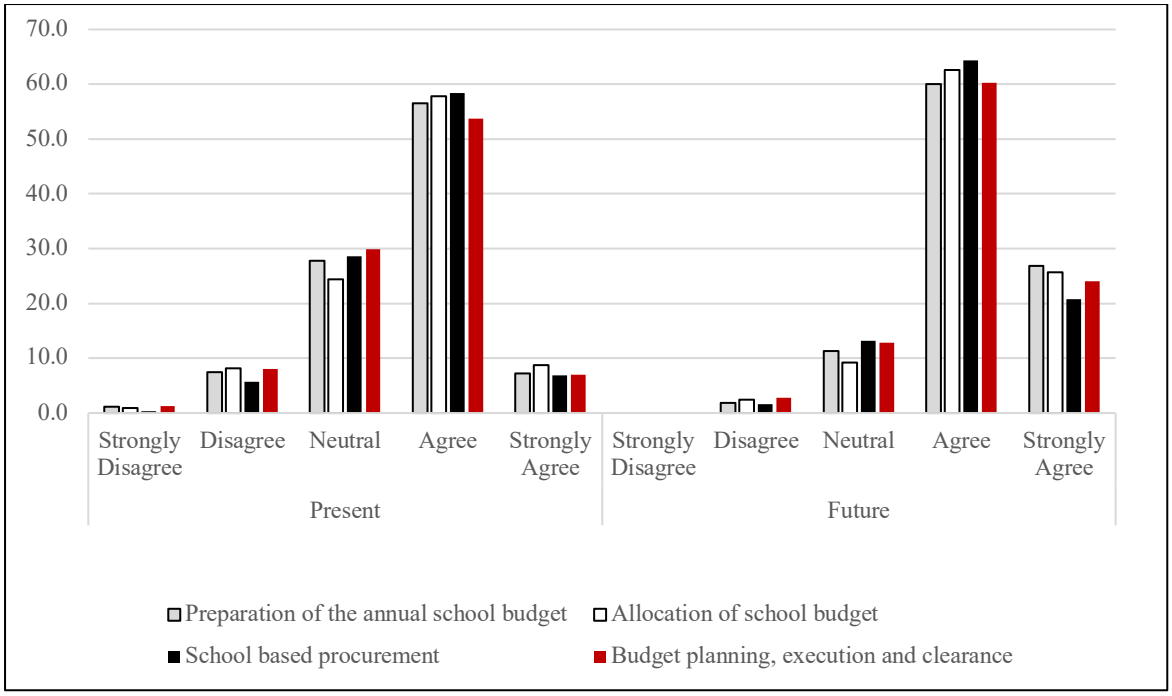


***Figure 6*:** Teacher is involved in the preparation of the annual school budget, in the allocation of school budget resources based on the needs of the school, in school-based procurement, and in budget planning clearance

3.3. Curriculum and Instruction

Curriculum reform was also one of the key elements of proposed systematic educational reform. A curriculum is a tool that is designed to educate students with a purpose in mind of what the country wants them to be for national services in the future, and instruction is a means of knowledge delivery from teachers to students as part of a designed curriculum. Therefore, curriculum and instruction are closely and symbiotically correlated and the quality of education will never reach the goals of the nation if these two functions are broken apart. The two should be strengthened simultaneously and sheltered under the same umbrella. To assess the implementation of curriculum and instruction in target schools, it is necessary to identify the degree of working unity and collaboration amongst involved personnel, such as school principals, teachers, and school management committee. Their coordination should be evaluated in terms of setting the school vision on learning outcomes and drafting school plans, setting instruction times for academic subjects, the school calendar and course syllabi, distributing textbooks, assessing student performance, and developing student tests.

As seen in **Figure 7**, a majority of respondents agree that they are involved in textbook distribution, student assessment, and test development. In this sense, most of the school principals have paid significant attention to involvement in student assessment and test

development for learning progress. It is likely they comprehend the importance of their participation is as a number of respondents (double the number that indicated participation at present) expected to get more involved in the future. Meanwhile, some school principals are not involved in textbook distribution, student assessment, and test development at the present and do no plan do do so in the future.

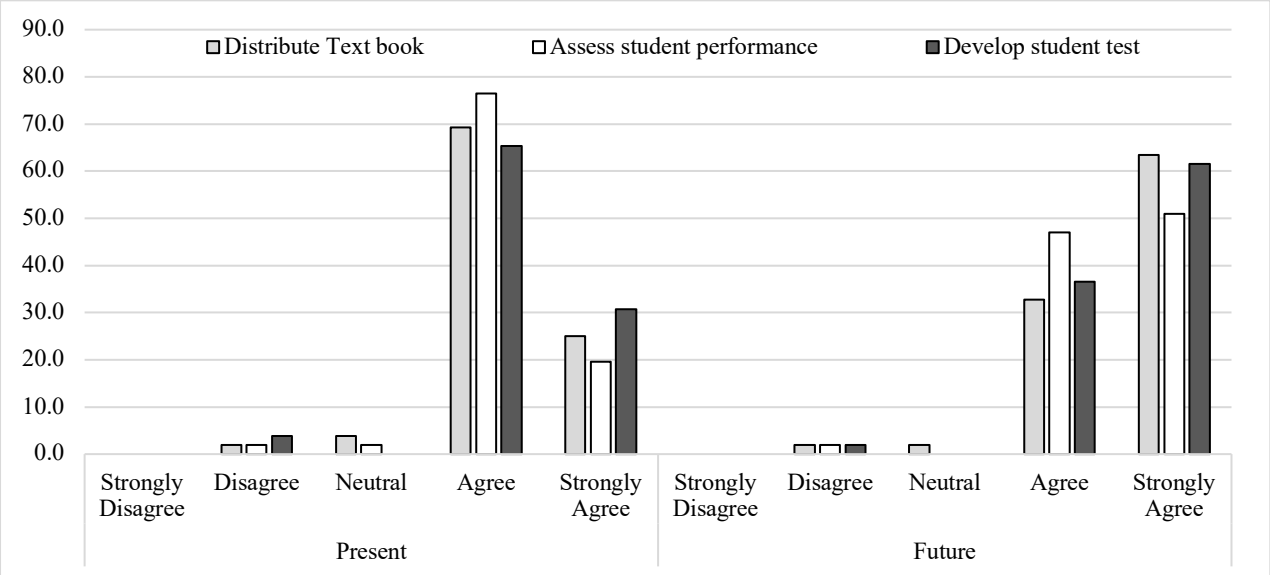


Figure 7: School directors distribute textbooks, assess student performance, and develop student tests

According to the data collected (see **Figure 8**), teachers are sufficiently autonomous in their field of teaching given that most of the respondents agree and strongly agree that they are involved in the teaching and learning activities of students. For example, over 90 percent of teachers have been involved in assessing student performance and developing student tests, proving that all current practices of teachers are in line with school-based management. In addition, it was noted that teachers have held themselves accountable for the learning outcome of students. To the degree that there is performance accountability, teachers are working hard and daring to accept the result of their students. As observed, the teachers expect to obtain more autonomy in their field in the future as the number of strongly agreed respondents is double the number showing agreement regarding the situation in the present. This supports the view that, if they are provided more spaces of autonomy, they would enthusiastically fulfill their duties. School management committee, they showed less involved in curriculum and instruction development given that numerous members of the committee, accounting for over 70%, admit that they lack the ability and technical skill for instruction of the students and teachers. However, they can do monitoring and evaluation of the processes of teaching and

learning, given that 68 percent of respondents said they have been involved in those activities. Also, the rate of those that predict to be involved in those activities in the future increases to around 90%.

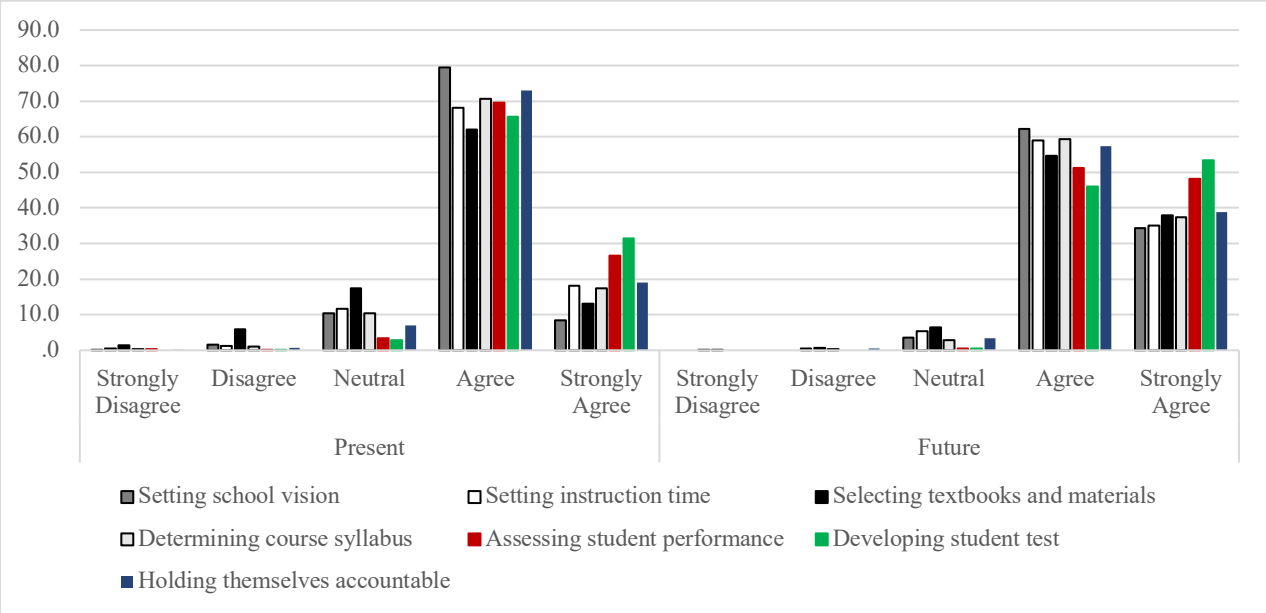


Figure 8: Teacher is involved in setting the school vision for learning outcomes and develops student tests.

3.4. Resource management

With respect to the current situation, a number of school directors and school management committee, corresponding to 94% and 55%, respectively, agree that they have an autonomy in terms of: resources management; including mobilizing and using resources from various sources; making a purchase orders; involving teacher, parents and school management committee in SBM; and, doing fundraising at the local level. At the same time, a moderate number of teachers mentioned that, they did not want to involve in resources management and fundraising activities in addition to teaching. Also, 80% of teachers agreed that they do get involved in developing school physical resources and facility planning. As noted, a larger number of the involved parties (school director, teacher, and school management committee) wish to participate in all varieties of school activities in the future.

3.5. Staff management

A majority of school principals responded that they are capable of monitoring and evaluating the internal staff. Also, most principals indicated that they have involved the teachers and the school committee in the preparation of needs-based staff recruitment, in the

decision-making of staff recruitment, and in preparation of teacher professional development plans. However, some of them remain uncertaint regarding their capacities (see **Figure 9**). Importantly, they strongly agree on the necessity of monitoring and evaluation for effective school leadership and expect in the future to enhance their professional capacities to conduct these activities. The number of respondents indicating agreement increases from 15% with regard to the present to 55% with regard to the future. The results suggest that professional improvement and development should be readily accessible as part of an ongoing process of continuous education in order to improve their capacities for monitoring and evaluation of the staff more effectively. The data presented in **Figure 9** also illustrates school principals have the authority to make teacher recruitment decisions and have a vital role in the professional development of teachers. Regarding the topic of teacher recruitment, the data obtained show a varied range of responses. Some school principals responded that they have no authority to make decisions on teacher recruitment and termination and expressed uncertainty regarding their authority, while others agree that they have authority to make a decision by submitting a proposal letter for recruitment or termination to the District Office of the Ministry of Education, Youth and Sport. The response received reflects different understanding of roles, procedures, and authority despite the fact that respondents belong to a single system. Results indicate that some schools are able to recruit and terminate the contract staff (teachers, office workers, and security officers), while others are either not able or unsure about their authority to recruit and contract staff. A larger number of school directors would like to get more authority in the future to manage the staff independently, including recruitment and termination.

Lawfully, the principals are not allowed to recruit state teachers, in turn, they can recruit contract staff. Drawing froms the result, it is obvious that some principals are still uncertain in the role; therefore, it is needed to create a clear guideline and more widely disseminate to the school staff regarding the policies and procedures of staff recruitment in order to ensure consistency in principals' practice and conformity across schools. It was noted that numerous principals strongly agree they expect to be grant more autonomy to recruit staff on their own volition in the future. Similarly, on the practice of teacher professional development, about 70 percent of principals agreed that they have an active role at present and 90 percent expect to have such a role in the future. This demonstrates reflecting that numerous principals see the value of capacity-building for teacher as positively contributing to student learning outcomes. However, about 20 percent remain unsure about this role, and about 5 percent do not have an active role (**Figure 9**).

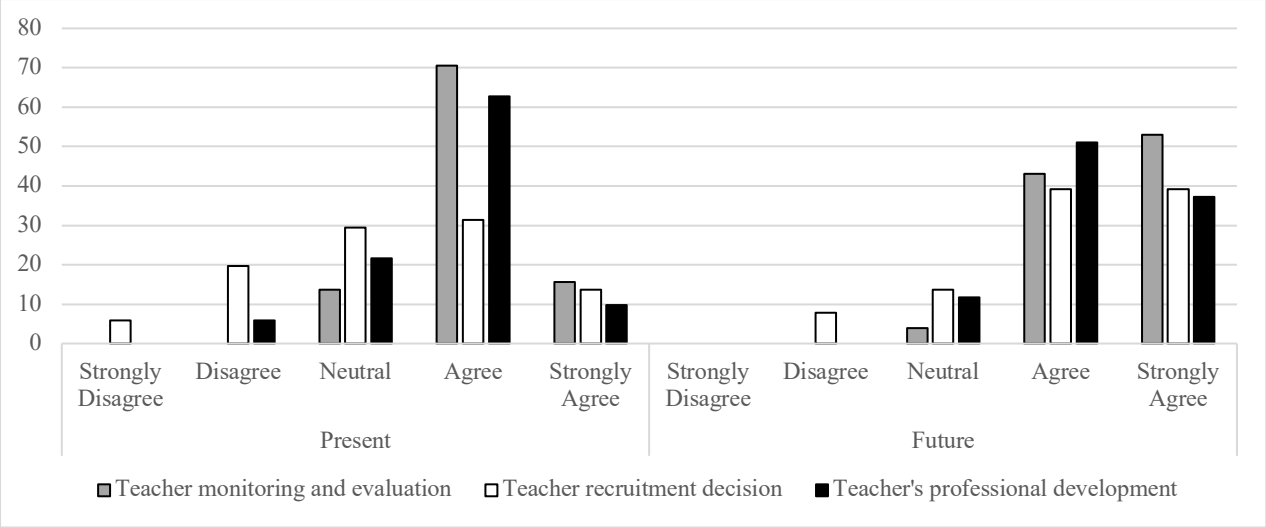


Figure 9: School directors have the capacity to carry out teacher monitoring and evaluation, have the authority to make teacher recruitment decisions, and take an active role in the professional development of teachers

4. Conclusion

School-based management has been emphasized in education reform at the school level. It is expected to have a direct impact on improving student learning achievements, retention rates, completion rates, and promoting the value of education and community participation. However, it might be a challenging issue and and a cause of concern in the education system as a whole if it is not properly handled. In SBM schools, school board directors, teachers, and the local community are key drivers in determining the destiny of students. A number of main areas in SBM schools, have been addressedin the current study, including school leadership and management, budget management, curriculum and instruction, resources management, and staff management.. The results showed that the current implementation of SBM in schools is fundamentally on the right track because of the involvement and cooperation of school directors, teachers, and members of the school management committee. It is an initial positive sign of growth to carry on the SBM platform in Cambodia's future education. However, to better achieve outcomes, consistent and solid support must be provided to those involved at the schoold level, given that a substantial number of them do not fully understand the SBM concept, guidelines, and practical implementation. Hence, they are still reluctant to deliver their services according to the individual roles and duties. These findings can inform current practices and also contribute to future SBM policy interventions and their application in practice.

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Ministry of Education, Youth and Sport
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Article

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 locations of secondary resource schools. This paper, in particular, focuses on 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 secondary resource schools. This study relies primarily on 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 compare with qualitative findings. In addition, Measure Distance Map App was also used to collect latitude and longitude data on each school location for the spatial analysis. In our detailed study in Kampong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh we found that: establishment of the secondary resource schools has contributed in a promotion of STEM; despite that. school networks were not sufficiently beneficial due to insufficient transportation cost, limited capacity; weak operation and management is a continuing challenge. (1) 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 network schools. (2) An average distance between secondary resource schools and network

schools was 4.2 kilometers, ranging from 2.0 to 9.4 kilometers; it was the furthest in Kratie and the nearest in Banteay Meanchey. (3) The spatial analysis reveals that the existing secondary resource schools are not central which leads to difficulty of access by network schools. (5) Samdach Ov or Serey Sophoan Upper Secondary Schools for Banteay 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. () There are four key problems or constraints which limit the impact of the secondary resource schools. They include social norms, capacity, operation, and management.

***Keywords*:** Science; technology; science, technology, engineering and math engineering and mathematics (STEM); spatial analysis; secondary resource schools; Cambodia

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1. Introduction

In 2015, STEM (Science, Technology, Engineering and Mathematics) was introduced when the First Cambodia's Science & Engineering Festival (CSEF) was organized with the impressive attendance of 10,000 people.[2] Moreover, the Industrial Development Policy of Cambodia (2015-2025) has 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 a fact that STEM education addresses the practical application of knowledge to real-world problems for economic growth and social development based on creativity, problem-solving, and critical thinking (Machuve & Mkenda, 2019). As the result, STEM has supports the increasing demand for skills needed for adapting to the fourth industrial revolution (Armbrecht, 2016) and for generating economic growth (Engler, 2012, Kaing, 2016). According to Pimthong and Williams (2018), each discipline of STEM does not exist alone, but, they are interrelated as complex and multidimensional problems combine different elements. An integration of STEM concepts and

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

processes among young people through participation in multidisciplinary situations help to prepare people for their future life and for the workforce (English, 2017).

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, as its Gross Net Income (GNI) per capita was had reached $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 the Teacher Policy Action Plan (2015-2020). In 2015, the MoEYS set out that all teachers will have at least a Bachelor's degree by 2020 to ensure their capacity to educate the next generation of professionals (Blanquat & Associates, 2016). In promoting STEM education, the MoEYS has worked at various levels to formulate school streams: science vs. social science (Kao 2013). At the same time, the necessary infrastructure and resources are being equipped at secondary schools and at universities for students to support majors in the fields of STEM (MOEYS, 2018). Education is also necessary to support the country in achieving its ambition to transition from a lower-middle income country to being an upper-middle income country by 2030, and to a developed country by 2050 (MoEYS, 2014). As clearly stated in the government's strategy, STEM education is aimed at strengthening sectors which require skilled labor among young learners and professionals (Blanquat & Associates, 2016). As one of the 10 country members in the Association of Southeast Asian Nations (ASEAN), Cambodia is striving to expand employment markets for young Cambodians to be at an advantage in the ASEAN Economic Community through access to STEM careers, and to reduce its economic dependency on the garment and tourism sectors (Anonymous, 2015).

In general, science and mathematics education are delivered from primary to secondary schools worldwide, but in the engineering field of study they are included at higher education (Holmlund et al., 2018). While technology courses are provided by vocational education, it is also somewhat included at the secondary level (National Science Board, 2015). In recent years, teachers at secondary schools have engaged in innovative new approaches and include more STEM education in their classrooms. As a result, the higher quality of science education at the secondary level contributes to developing scientific literacy and understanding which enables students to pursue sciences and engineering at the university level. In the other word, generating higher levels of participation in science-related studies at university is associated with the improvement of science education at secondary schools (Ainley et al., 2008). However, even though STEM education has been integrated into the school curriculum from the primary to the secondary level, there are still many constraints in promoting STEM literacy.

Those challenges include insufficient content integrated into national curriculums, lack of resources and facilities, insufficient competent teaching staff for science and engineering, and the perception of students that the subjects are too difficult. According to the Ministry of Education Youth and Sport (MoEYS) in 2015, instruction in science, math, and technology was provided at the secondary level, but a nation-wide required curriculum did not exist.

For example, the lack of engineering concepts in the secondary school curriculum may be a contributing factor to the low rates of students pursuing study in this field. Among countries in ASEAN, the low number of students enrolling in the engineering field of study in Cambodia has become a noted concern in this region (ASEAN Secretariat, 2007). Moreover, secondary schools are faced with a lack of facilities, resources, and qualified teachers to support STEM education, which is needed to be aligned with regional and international standards for curriculum and instructional practices (USAID, 2010). Students perceive STEM education include difficult subjects because there were few opportunities for students to engage in practical application and experimentation. Today, there are too many business graduates, creating a surplus of job seekers in that sector, and while STEM sectors do not have sufficient human resources (Kaing, 2016). Currently, improvements in the availability of resources, experimentation, and teaching methods have not yet attracted students or improved their understanding or performance in STEM-related studies (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. Sme education specialists have argued that students at the secondary level require opportunities to engage in laboratory experiments and scientific investigations (Achieve, Inc., 2013). At secondary schools, laboratory practice is crucial (Luft et al., 2011) because students are involved in improving scientific skills (Suleiman, 2013), communicating their ideas to others (NRC, 1996), and establishing the accuracy of their beliefs (Angus & Keith, 1992). Teaching methods in the classroom alone are not enough, as the improvement of student understanding and recollection of information through experimentation and practice help developing problem-solving and critical thinking skills (Kigali Institute of Education, 2011). Moreover, the provision of the necessary equipment for experiments and practical activities in science must be aligned with the daily life of the students (Ogunmade, 2005). Under the supervision of teachers, the experiments and demonstrations are carried out by the students by applying theoretical knowledge with practical activities done in the laboratory, classroom, and field work (Tytler, 2007). Sandifer & Haines (2009) have found that hands-on activities are the best strategy for effective science teaching and learning.

The Global Competitiveness Report 2017–2018 concluded that the quality of math and science education in Cambodia is ranked at 111 out of 124 countries. During his first mandate, the Minister of Education H.E. Dr. Hang Choun-Naron has made significant advances in educational development. The establishment of secondary resource schools has been one of his efforts aimed at delivering well-rounded education services to the communities. In early 2011, the Asian Development Bank (ADB) funded the Education Sector Development Project II (ESDP II) which included the construction of 18 secondary resource schools in Cambodia. Today, 50 secondary resource schools have been constructed throughout the country and each secondary resource school is part of a network of up to eight secondary schools for the purpose of sharing resources. A purpose of the project is to improve quality and equity of education in Cambodia with more effective secondary education, improved teacher competency, and stronger education management practices. In aiming to make secondary resource school to be sites for increased learning and teaching resources, they are equipped with computer labs, libraries, science labs, meeting rooms, and a teachers' room. In particular, secondary resource schools have played very important roles in promoting STEM education by providing the opportunity for students to engage in experiments and practical work linking theories learned in the classroom and real-world applications.[3] Accordingly, this paper aims explore to approaches to enhance STEM education in Cambodia through doing spatial analysis for the location of secondary resource schools by focusing on spatial distribution of secondary resource schools, appropriate location for secondary resource schools, and problems and constraints in the management of secondary resource schools.

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

2. Research methodology and secondary resource school

This study employs both exploratory research and descriptive research methods to examine the research questions. This study relies primarily on 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 compare with qualitative findings. In addition, Measure Distance Map App was also used to collect latitude and longitude data on each school location for the spatial analysis. During the field work, semi-structured questionnaires were applied to collecting qualitative data from school management teams at host secondary resource schools and the schools' networks in Kampong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh. In each study province, one secondary resource school and three network schools (at least) were selected for the interview (Table 1). The interview focused upon how secondary resource schools are located, operated, and managed. In addition, the interviews also investigated how secondary resource schools are beneficial to STEM education in the host school and school network. Key informant interviews were made by using an unstructured questionnaire to collect qualitative data from the Ministry of Education Youth and Sport, and the Provincial Department of Education Youth and Sport. The interviews were held, as well, to explore possibilities for policy and program intervention regarding to the management of secondary resource schools. Ultimately, the interviews helped to understand better the role of the MoEYS in supporting the operation and management of the secondary resource schools at national and sub-national levels.

Both quantitative and qualitative analyses were applied. They included desk review and problem analysis. Desk review is an important part of the assessment by collecting, organizing and synthesizing available reports and previous publicaton. This enabled the researcher to gain an understanding of the context involved and results produced in the operation of secondary resource schools. The desk review also helped to identify problems and obstacles faced by the secondary resource schools. Problem and situation analysis facilitated exploration of the general position or context in which the secondary resource schools and networks operated. The findings elicited from using this technique provided the contextual knowledge needed for assessing the management of secondary resource schools.

Table 1

List of respondents for in-depth interviews and key informant interviews

No.	Institution		No.
	Unstructured questionnaire for key informants		
1	Ministry of Education Youth and Sport	General Secondary Education Department	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 in-depth interviews		
4	Provincial Department of Education Youth and Sport in Kampong 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 School	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 used to test whether there was significant difference between the mean distance between secondary resource schools and network schools in the five study areas. The correlation analysis was used to test the association of numeric variables between the number of resource schools, number of secondary schools, and number of network schools. ArcView software was applied to map secondary resource schools and school networks in Cambodia and to explore the best location for resource schools in Banteay Meanchey and Phnom Penh.

In 2004, the MoEYS received loans from the ADB to implement the Second Education Sector Development Project (ESDP II). The project was implemented between 2004 and 2008 in order to enhance equitable access to education by improving the quality of lower and upper secondary education and providing demand driven community-based skill training opportunities, primarily for out-of-school youth in under-resourced areas. The project completed 18 of the 24 originally planned upper secondary resource schools, and equipped them with science and computer facilities. Moreover, the MoEYS delivered multi-day training sessions for 243 science teachers, and a separate secondary resource school management workshop for provincial directors, school directors, and task force members. Consequently, before project completetion, it was not possible to properly evaluate SRC operations and provide adequate oversight. This has had an impact on management efficiency, and ultimately limited student access to quality science teaching (ABD, 2012). After completion of the ESDP II, the Enhancing Education Quality Project (EEQP), carried out between 2008 and 2014, was designed to make substantial improvements in the quality and efficiency of the secondary education sector. The overriding objective was to strengthen the capacity of the agencies responsible for the delivery of quality education. The project was completed with a successful assessment which utilized the ratings of highly relevant, effective, efficient, and partly sustainable. Under the EEQP, 18 secondary resource schools were built.[4]

The project helped to improve school capacity management, to increase school outcomes, to develop a teacher policy which will have an ongoing impact, to maintain functional MIS, to

[4] See detail: http://www.moeys.gov.kh/en/eeqp/tu-3-strengthening-secondary-education/secondary-resource-centers.html#.Xj7XCWgzY2w

create quality control systems in TTCs and schools, to conduct training in ICT and multimedia, to establish multimedia center for the NIE, to improve the safety and security of facilities, particularly for women, to significantly improved teaching and learning facilities, and to enhance assessment techniques, textbooks and teacher guides. But, it was less successful in sustaining the full capacity of use by the SRC and this will need to be achieved over time. The project also undertook many additional tasks to enable the ESDPII, with SRCs to be incorporated into the implementation plans for the EEQP (MoEYS, 2015). According to the Asian Development Bank, the proposed Second Upper Secondary Education Sector Development Program (USESDP 2) is part of the phased support of the ADB for the development of high-quality human resources by improving the effectiveness of upper secondary education (USE). The USESDP 2 builds on and complements ADB's ongoing Upper Secondary Education Sector Development Program (USESDP 1). The program will (i) improve teacher quality and boost the quality and labor market relevance of USE; and (ii) strengthen institutional capacity for USE planning, management, and delivery. While the resulting policy reforms will apply nationwide, the project activities will cover only selected areas.

3. Results and findings

3.1. Contribution of secondary resource schools in promoting STEM education

In 2004, secondary resource schools were initiated by the MoEYS and the Asian Development Bank (ADB). Construction and operation of secondary resource schools has been funded by the ABD in three different projects 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) project, 18 resource schools were constructed and labelled 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 the fields of Science, Math, and Information Communication Technology. In order to establish resource schools across the country, the ADB provided further funds under the EEQP (2008-2014) to construct another 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, the ADB funded 14 more

secondary resource schools under the USESDP project. The project was targeted to improve the quality of human resources at the upper secondary education level, needed for sustaining Cambodia's economic growth and social development. By the end of December 2019, there were 50 resource schools functioning in Cambodia (Figure 1).

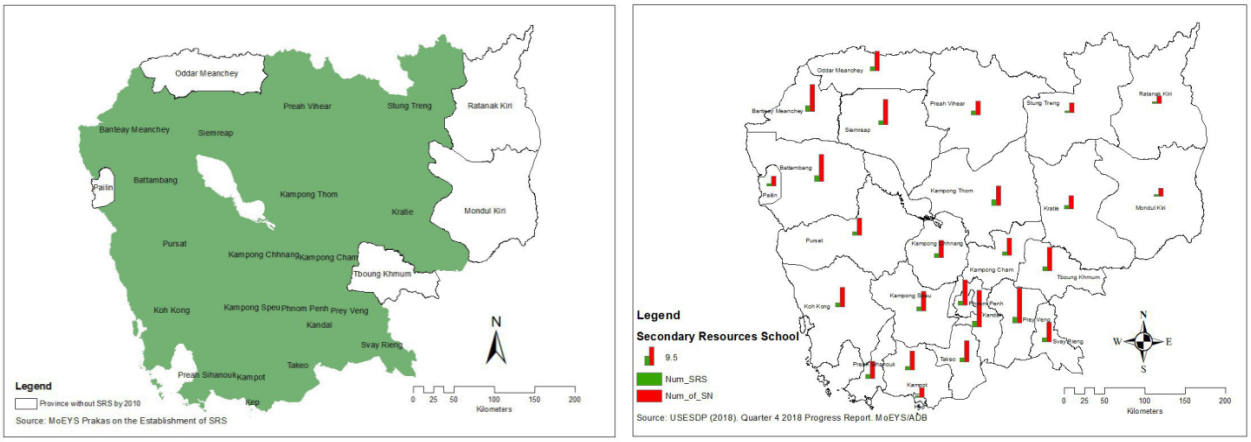

***Figure 1*:** Mapping secondary resource school and school networks in Cambodia

Today, secondary resource schools are in operation in all the 25 provinces and cities across the country, with the number in different provinces varying due to demand and the availability of funds from ADB. On 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 such as Banteay Meanchey, Battambang, Kampong Thom, Kandal, and Prey Veng, host up to three secondary resource schools, ADB only provided for one secondary resource school in the provinces of Mondulkiri, Kep, Pailin, Ratanakiri, and Stung Treng. Other provinces each host two secondary resource schools. The research, using correlation analysis illustrated in Figure 1, found that the number of resource schools was positively and strongly correlated to the number of students (P-value=0.000), to the number of secondary schools (P-value=0.000), and to the number of network schools (P-value=0.000). On the basis of these findings, it can be confirmed that the construction of secondary resource schools in Cambodia directly responded to the real needs of students at host schools and school network institutions, for the promotion of STEM education. The higher number of students and secondary schools reflects the higher number of secondary resource schools established.

According to the Department of Secondary Schools at the MoEYS, the secondary resource schools have been established to increase the opportunity for access to experimentation and practice in the sciences. The secondary resource schools have been established in a city center or provincial town. Each 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 network schools are able to access facilities of the secondary resource school for the purpose of doing experiments and practical learning [Pers. Comm. MoEYS]. The host schools have been funded with the annual budget for operation of the secondary resource schools, as well as the purchase of materials and equipment, and, a scholarship scheme for poor students. However, students and teachers at school networks only receive budget resources to cover their transportation and the purchase of materials and equipment.

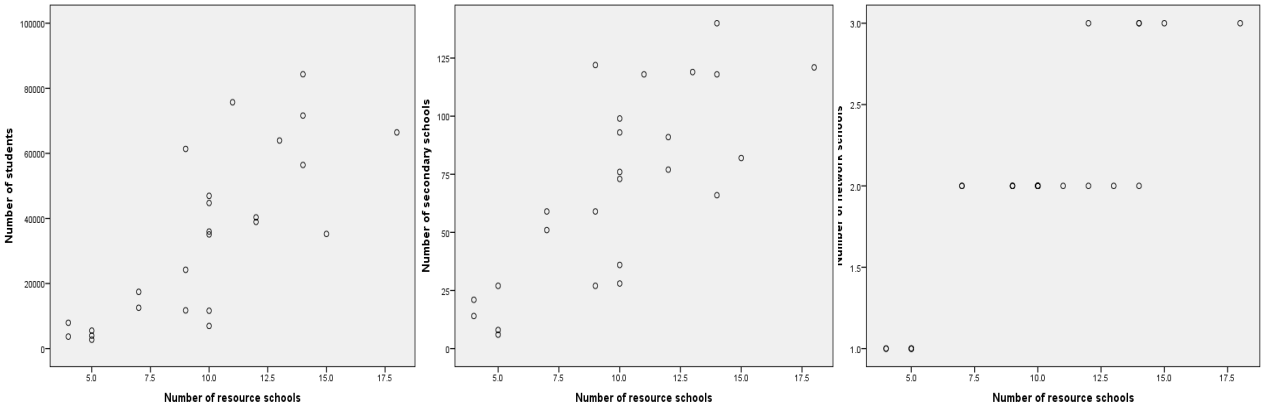

Figure 1: Association among resource schools, secondary schools and network schools

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

The interviewee, from the interview of a staff member at Chbar Ampeouv Upper Secondary School, revealed 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 funding was previously from ADB. From this year, it is now allocated by the MoEYS under Public Budget (PB). I get additional 5 million Cambodian riel, so it is now a total of 40 million Cambodian Riel." [Pers. Comm. Chbar Ampeouv USS]. Since 2019, the MoEYS has allocated the annual budget for operation of secondary resource schools, after completion of the EEQP project. To increase the use of secondary resource schools, the USESDP is designed to provide an annual budget for transportation and purchases of materials and equipment. Both host schools and network schools are now annually funded with 500 US dollars to pay for transportation of teachers and students, and to buy chemicals required for their experiments at resource schools [Pers. Comm. MoEYS]. A school principal expressed that:

> 'I think the secondary resource school is very useful because it gives an opportunity to my students to do experiments and to practice in earth science, physics and biology. Through MoEYS, ADB are funding my school with 500 US dollars. The amount may be very small for

> other schools but it is a lot for my school. With that support, I can bring my students to practice at Hun Sen Khlar Koum secondary resource school 10 times per year. I think other schools can 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 available around my school.' [Pers. Comm. Serey Sorphorn USS]

In principle, a secondary resource school functions with support of four staff: one staff for the laboratory, two staff for Information Technology (IT), and two contract staff to support other work required at the secondary resource school. The building has facilities and equipment to promote STEM education for the host schools and the network schools, especially physics, chemistry, earth science and biology [Pers. Comm. PDoEYD in Phnom Penh]. The operation of resource schools across Cambodia has been very beneficial for students at secondary schools when they enroll at university. Students are familiar with the courses from the experience with experimentation and practice found 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 understanding of theories learned in the classroom. In addition, students from poor families have also been provided scholarship to support their studies [Pers. Comm. MoEYS]. Under the USESDP project, the ADB has agreed to provide scholarships for students, with each secondary resource school being granted 15 scholarships. A student receives 200 US dollars per year for a period of 2 years. This academic year (2019-2020) was the third year of the arrangement [Pers. Comm. PDoEYD in Phnom Penh]. To date, the MoEYS has considered establishment of secondary resource schools as the most cost-effective strategy to promote STEM education at secondary school level in Cambodia. It is a fact that the MoEYS is not able to equip laboratories, computer labs and libraries at all secondary schools across the country. One respondent pointed out: "Only the cost of renovating a classroom for a laboratory is roughly 60,000 US dollars and it does not include the equipment and facilities. How can the Ministry invest in laboratories of the school. For example some schools in remote areas have only fewstudents enrolling at secondary level. They must use the facilities and equipment available at the secondary resource school." [Pers. Comm. MoEYS]. "At the same time, parents of students at Kratie Krong Upper Secondary School applauded the school and were optimistic about its impact. The schools in the rural areas now have modern computer labs, laboratories and libraries for students to practice." [Pers. Comm. Kratie Krong USS].

3.2. 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 the center of the city or province. Second, there must be sufficient teachers to be responsible for all subjects. The third and fourth criteria are that the school must be equipped with utilities such as electricity and water. The fifth and sixth criteria are that the school is strongly supported by the community and has good management. Having sufficient land for the development is the last criteria. [Pers. Comm. MoEYS] When all the schools wish to establish a laboratory at their own location, bias or jealousy about the selection of secondary resource schools cannot be avoided. The officer at the Department of Secondary Schools explained: "I used to get reactions and complaints on social media by teachers at remote schools about the location selection of secondary resource schools. They are not happy and feel that we [the Ministry] have abandoned the promotion of science in remote schools. During the interview, the offer at the MoEYS also explained that it is not yet now cost effective to locate a secondary resource school in remote areas because of the low number of students the laboratory equipment is not fully used [Pers. Comm. MoEYS] . '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 a computer lab, laboratories, a library and a place for students and teacher to do group learning activities to upgrade their understanding of science [Pers. Comm. Hun Sen Chamkar Dong UPP]. During the field work, school principals provided different reasons why their schools were selected to host a secondary resource school. One stated:

> '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 comfortable 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 the school principal at Hun Sen Khlar Koun Upper held that it had the best location and a large campus, it was quite hard for the school principal in Banteay Meanchey to suggest the best location to be conveniently accessible by all network schools. For example, there are four upper secondary schools in this province: Samdech 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, the campus is a bit small. But it is good to be at Serey Sorphorn Upper Secondary School

because the school includes all levels, from primary to upper secondary" [Pers. Comm. Sandech Ov USS]. Similarly, the school principal at Hun Sen Chamkar Dong Upper Secondary School did not agree that the best location should be the sole criteria for the selection of the host school for the SRS in Kep province.

> The main reason for selecting this school as a secondary resource school is that it was, at the time, the only upper secondary school available in town. Also, our school has a big campus. Moreover, the school had the highest number of students enrolled at that time. We have five network schools. 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 outstanding in terms of national examination results at the upper secondary level, student performance, and enforcement of morality. At first the plan was that this school would host the New Generation School (NGS) but it was later chosen to be the site of a secondary resource school. The MoEYS ascertained that Hun Sen Balang Upper Secondary School did not yet fulfill the criteria to host the NGS program [Pers. Comm. Hun Sen Balang USS]. The equipment and facilities available at secondary resource schools are managed by host schools, but they are shared for use by network schools. The network schools prepared schedules for bringing students to practice and to do experiments at the laboratories set up at the secondary resource schools.

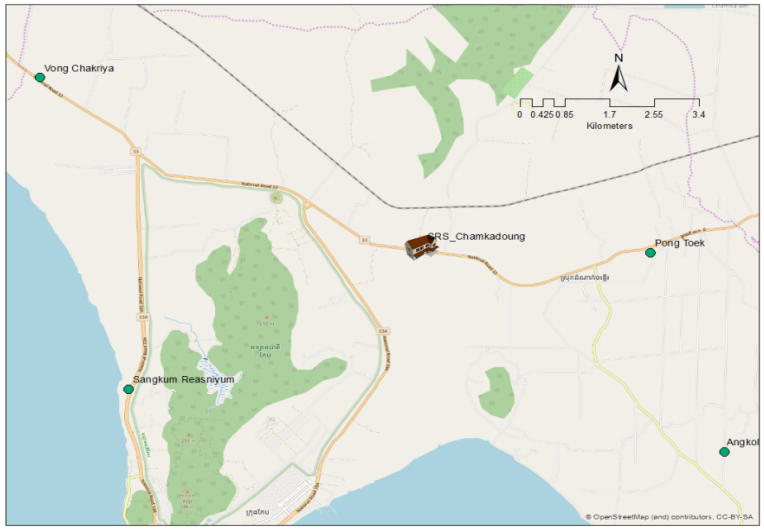

Figure 2. Location of resource school in Kep

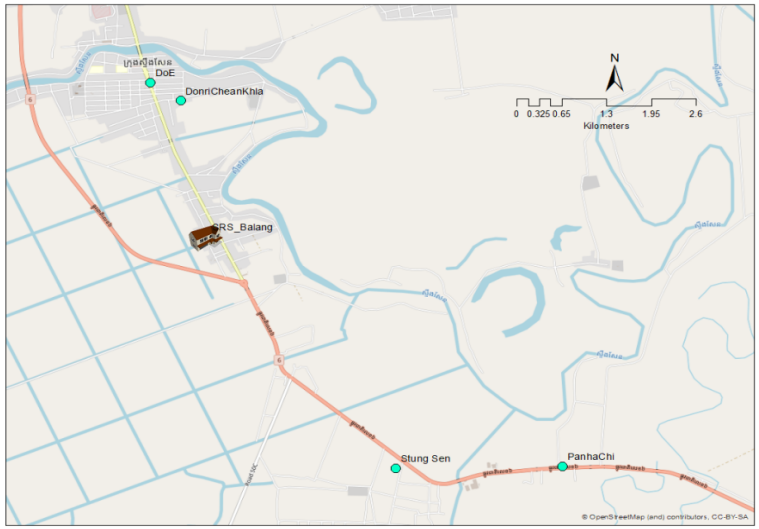

Figure 3. Location of resource school in Kampong Thom

Figure 4. Location of resource school in Kratie

Figure 5. Location of resource school in Banteay Meanchey

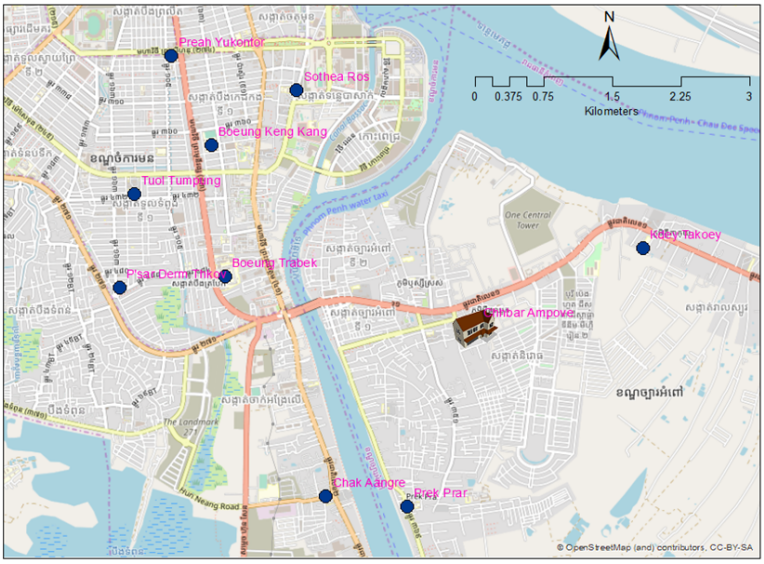

Figure 6. Location of resource school in Phnom Penh

According to spatial analysis of the existing secondary resource schools in Kampong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh, there are some challenges related to the distance between secondary resource schools and network schools (see Figures 2-5). However secondary resource schools are mainly located in provincial or city centers, resulting in many schools with limited access because of the far distance. At the same time, all of the network school officials expressed the desire to have their own laboratories. Network schools in remote areas did not have the means to transport their students to the secondary resource schools. Moreover, secondary resource school equipment/facilities tended to already be in full use by the host schools. [Pers. Comm. MoEYS] Figure 6 illustrates the average distance from the secondary resource schools to network schools was 4.2 kilometers, with individual distances ranging from 2.0 and 9.4 kilometers. According to ANOVA test results, Kratie was the furthest (7.1 kilometers) and Banteay Meanchey was the nearest (2.8 kilometers) (P-value = 0.000). In Kratie, there was one secondary resource school called Kratie Krong Upper Secondary School and it had only two network schools (On Chanh Lower Secondary School and Ka Po Lower Secondary School). On Chanh Lower Secondary School is located 9.4 kilometers away from Kratie Krong Upper Secondary School, and the distance of Ka Po Lower Secondary School to the resource school is 4.9 kilometers.

The distance from Hun Sen Chamkar Dong Upper Secondary School to its network schools[5] makes it fairly central. Given that, it is unlikely that the furthest school would find it very hard

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

to take students to the secondary resource school, and they would still have most of the morning or afternoon session to use for their experiments. 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 School and 7.1 kilometers for Hun Sen Angkor Lower Secondary School. The school principal at Hun Sen Krong Kep Lower Secondary School pointed to both advantages and disadvantages in sending students to the secondary resource school. The students are able to do experiments and practice 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]. Similarly, the school principal at Bun Rany Hun Sen Chakriya Vong Upper Secondary School raised concerns about the distance and the fact that students are required to find their own transportation to the secondary resource school. He emphasized that the school cannot be responsible for any incidents which befall students and/or teachers during their travel. The school principal complained: "it is waste a lot of time to travel to the 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]

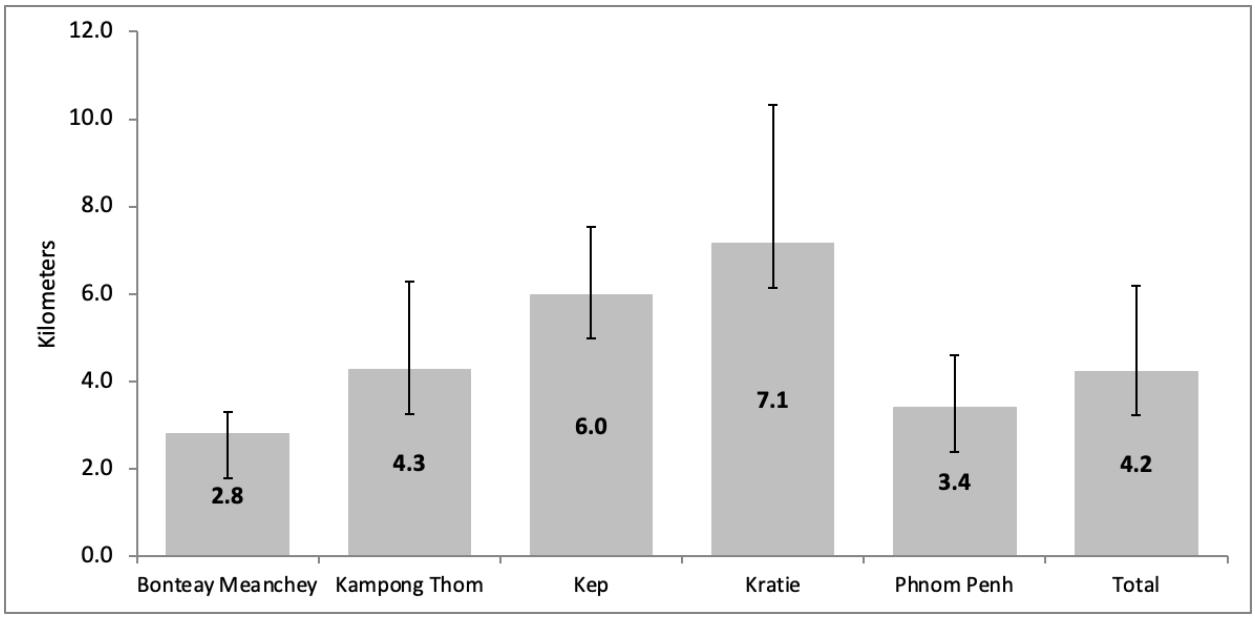

Figure 7. Mean distance to resource schools

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 suited for the SRS, but, there means a challenge for Pangha Chi Lower Secondary School. That school is located as far as 8 kilometers away from the secondary resource school. Damrei Chorn Khlar Lower Secondary School had the best access location for network schools compared to the other two options. The distance from Damrei Chorn Khlar Lower Secondary School to Hun Sen Balang Upper Secondary School is only 2.15 kilometers. As a result, the school principal at Pangha Chi Lower Secondary School was very satisfied secondary resource school. After having opportunity to do experiments, the performance of students improved [Pers. Comm. Panha Chi LSS]. In contrast, the school principle at Damrei Chorn Khlar Lower Secondary School identified the high risk of the long travel needed by students to make the trip to the secondary resource school. The principal clarified: "I do not think it is worth it 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, the people in charge are not there. It is also such a waste of time and money to spend on transportation with little results from practice and experiments. If we do it at our school, we can make better quality experiments and practice.' [Pers. Comm. Damrei Chorn Khlar LSS]. The Provincial Department of Education, Youth, and Sport shared a similar view that: "it is not so effective because of late arrival of either students, teachers, or the people in charge of the laboratory. At the same time, some students missed the session because of various reasons such as no transportation or laziness." [Pers. Comm. PDoEYD in Kampong Thom]

Among all the five geographical areas, the average distance between the secondary resource school and network schools in Kratie (7.1 kilometers) was the furthest, as shown in Figure 6. At Kratie Krong Upper Secondary School, parents were delighted that their children have the chance to study at a school where laboratories, a computer lab, and the library are well equipped. More and more parents are sending their children to study at Kratie Krong Upper Secondary School because students can practice after learning in the classroom. Some students from nearby districts also transferred to this school because they want to have better quality of education. [Pers. Comm. Kratie Krong USS] As the location of On Chanh Lower Secondary School is as far as 9.4 kilometers away from the secondary resource school, students had little opportunity to take part in doing experiments and practical learning. With the support from the MoEYS in the amount of 500 US dollars per year, the school is able to send students to the secondary resource school around 5 or 6 times per year. The distance from On Chanh Lower

Secondary School to resource school was quite far and hard for transportation [Pers. Comm. On Chanh LSS]

The average distances of the secondary resource schools were the shortest in Phnom Penh (2.8 kilometers) and Banteay Meanchey (3.4 kilometers) (see Figure 6 and Figure 5). In Banteay Meanchey, the Hun Sen Khla Koun Upper Secondary School is in the urban center. Therefore, it is not very far from the rest of the network schools. For Chbar Ampov Upper Secondary School, the school was located in central of Phnom Penh; but, some users still found it hard to commute to the secondary resource school, especially for those from Preah Yukuthor Upper Secondary School. There are three resource schools in Phnom Penh, but only two in operation, Hun Sen Champouvorn Upper Secondary School and Chbar Ampeouv Upper Secondary School. The resource school at Entrak Tevy High School is under construction and it is not yet operating [Pers. Comm. Chbar Ampeouv USS]. The new construction is expanding the coverage of network schools in Phnom Penh. The school principal at Chbar Ampeouv Upper Secondary School welcomed all students, teachers and researchers per request 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 meetings [Pers. Comm. Chbar Ampeouv USS]. With space for construction of a laboratory at Hun Sen Prek Pra Lower Secondary School [Pers. Comm. Hun Sen Prek Pra LSS] and no resource for construction of a laboratory at Tek Thlar Lower Secondary school [Pers. Comm. Tek Thlar LSS], the available secondary resource institution has provided a long-term support to many such secondary schools because they did not have space for construction of their own facilities.

3.3. 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 very low if compared to its neighboring Vietnam which expends 90 US dollars per capita per year. In promoting STEM education, facilities are very important because all science subjects require doing experiment and practice. Due to limited government budget resources, construction of laboratories and facilities/equipment for experimentation at all secondary schools in Cambodia is very challenging. the construction of more lower secondary in selected city or provincial center would remain a choice even in the next 10 years. The Ministry has no sufficient budget to construct laboratories at all the school across the county. However the distance of network school coverage is likely to gradually reduce from 20 km to 10 km radius from the resource schools [Pers. Comm. MoEYS]. In order

to reduce the burden on the secondary resource schools, the Ministry also has made budget allocations to some network schools for constructing their own small-size laboratories [Pers. Comm. Bun Rany Hun Sen Chakriya Vong USS]. In the future, spatial analysis will be useful for analyzing a suitable location which is more conveniently accessible to network school networks. In the research, two different geographical areas were selected as case studies to examine the question of how to identify the appropriate location for secondary resource schools among lower and upper secondary schools in Banteay Meanchey (Figure 7) and in Phnom Penh (Figure 8).

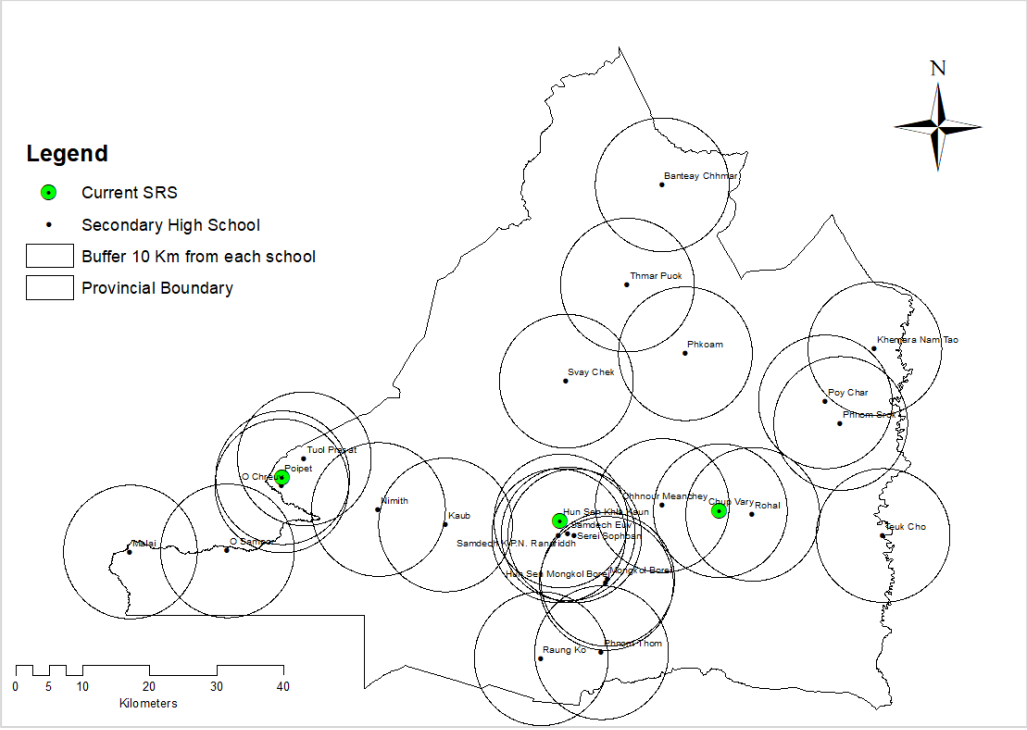

Figure 8: Appropriate location of secondary resource school in Banteay Meanchey

In Banteay Meanchey, three secondary resource schools were already constructed at Hun Sen Khlar Koun Upper Secondary School, Choub Veary Upper Secondary School and Poipet Krong Upper Secondary School. With spatial analysis, as illustrated in Figure 7, an appropriate location has been identified for the establishment of future secondary resource school in Banteay Meanchey. Similarly, spatial analysis can be applied in other provincial towns such as Kep or Kratie in order to find a more central Upper Secondary School to use as the host institution for the secondary resource schools. Figure 7 shows buffer zones, represented by a circle around the upper secondary schools which are represented by a dot on the map of Banteay Meanchey. Leaving aside the conditions of road access, the more circles around the

dot, the more central the location is. For example, Poipet Krong Upper Secondary School has three circles around it while Nimith Upper Secondary School has two circles and Malai has only one circle. So far, in Bantey Meanchey, the secondary resource schools have been central, or, within a 10 kilometer radius. Based on the analysis, Mongkol Borei would be the best option for the construction of resource school in the future since there were many upper secondary schools. In the future, secondary resource schools should probably be constructed at Samdach Ov or Serey Sophoan Upper Secondary Schools because they are more central and easier to be accessed by network schools.

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). Based on that criteria, the analysis finds that the existing resources were not conveniently accessible by network schools. For example, the distance between Preah YouKunthor to Chbar Ampeouv Upper Secondary School ranges from 5.9 to 6.2 kilometers. It may take 30 minutes by bus, or less by motorbike, and more than one hour by walking. Locating a resource at Chbar Ampeouv Upper Secondary School helps to improve the quality of STEM education in a more suburban area of Phnom Penh, but also creates commuting issues for students among network schools. The establishment of the secondary resource school at Chbar Ampeouv Upper Secondary School was 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 School. But, it has caused time consuming commutes for students from Beoung Trabek Upper Secondary School, Bun Rany Hun Sen Phsar Deoun Thkov, Preah Youkunthor Upper Secondary School, Toul Tum Poung Upper Secondary 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 commute. Moreover, it could be dangerous to let students go for individual transportation by motor bike or bicycle. The route to Chbar Ampeouv Upper Secondary School is one of the most traffic congested, especially during the peak hour. Students may be stuck there for hours if the traffic is heavy, and transportation definitely affects the schedule for network schools. Considering traffic congestion, safety concerns, and good access by the network schools, Santhor Muk Upper Secondary School is the most appropriate location for the future construction of a resource school. Moreover, Boeng Trabek Upper Secondary School location is optimal in terms of the distance from network schools. The location of the two schools are the most central in Phnom Penh for transportation from the network schools.

The establishment of a secondary resource school serves to create a primary education center for a geographic area. An SRS 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 now only accessible to network schools near to the provincial or city center. Schools located further than 20 kilometers from the provincial center were unlikely to access the secondary resource schools [Pers. Comm. PDoEYD in Banteay Meanchey]. At Damrei Chorn Khlar Lower Secondary School, the school principal hesitated to send students to the secondary resource school at Hun Sen Balang Upper Secondary School because he felt there is a high risk when traveling such a far distance [Pers. Comm. Damrei Chorn Khlar LSS]. According to the Provincial Office of Education Youth and Sport, secondary resource schools have attracted applications for the student transfers because parents believe their children would receive a better education. For example, students at Phnom Sroc Upper Secondary School loved science courses but a laboratory was not available. As a result, many students transferred to another school with a laboratory. However, given the current realities of development and resource limitations, it would be very difficult to equip advanced laboratories like those found at the resource schools at all schools across the country. However, it is still important to provide for a small laboratory in every secondary school, as it is hard for students to have a solid understanding of physics and chemistry without a laboratory [Pers. Comm. PDoEYD in Banteay Meanchey].

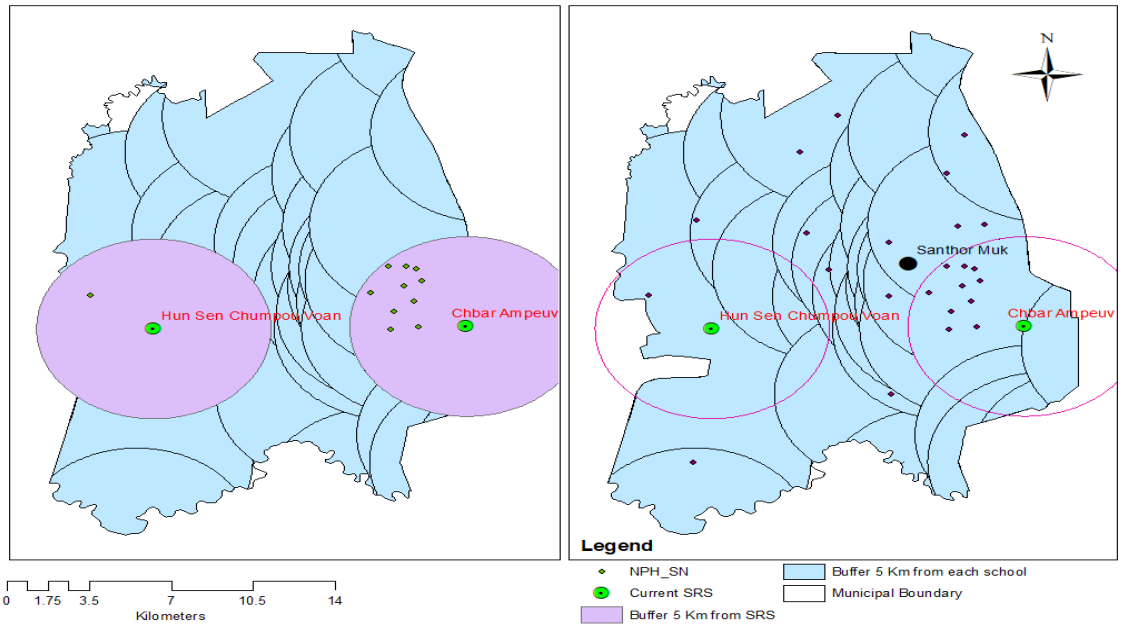

***Figure 9*: Appropriate location of resource school in Phnom Penh**

During the field work, all the host schools were found to be satisfied with the establishment of secondary resource schools, but almost all of network schools used the secondary resource

school did so only because of the instruction of the Ministry and because they lacked alternative facilities. In promoting STEM education, many schools started to develop their small-scale laboratories to enable their students to do experiments and practice. For example, the Porng Tek Lower Secondary School renovated three rooms for preparing its own experimentation 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 utilities such as electricity and water was one of the main obstacles, but it is not a problem anymore. [Pers. Comm. PDoEYD in Banteay Meanchey] By having a laboratory, students had opportunities to do more experimentation, however, the teachers did not have sufficient capacity for doing experiments. At Porng Tek Lower Secondary School, teachers only had the capacity to carry out simple experiments and repeat the same things. For example, many teachers of chemistry can only show students how to create oxygen, because they did not have any refresher training for new types of experiments. A lack of facilities, equipment and chemicals are also the issues. [Pers. Comm. Porng Tek LSS] At Hun Sen Krong Kep Lower Secondary School, there is no extra rooms for establishing an on-site laboratory, so teachers are buying portable chemicals/equipment to use in the classroom. [Pers. Comm. Hun Sen Krong Kep LSS]

3.4. Problems and constraints in managing secondary resource schools

An ultimate goal of establishing the secondary resource schools is to promote STEM education by improving facilities and equipment for practice and experimentation related to science courses. According to fieldwork interviews with all the key stakeholders including the MoEYS, the Provincial Office of Education, Youth, and Sport, school principals and officers in charge of secondary resource schools, five key problems are evident. These include obstacles in the areas of social norms, capacity, operation, and management which limit effectiveness of SRSs (Figure 9). Host schools stated that teachers and students from network schools were welcome to use the secondary resource schools [Pers. Comm. Hun Sen Khlar Koun USS]. Despite this, cultural and social norms have undermined the experience of teachers and students from network schools who come to use the secondary resource schools. The school principal at Hun Sen Chamkar Dong confirmed: “I have never heard any bad words from network school teachers. They were happy to use the secondary resource school here and thanked us for our help and cooperation. We have one staff standing by to assist them.” [Pers. Comm. Hun Sen Chamkar Dong UPP] In contrast, various negative reactions were collected

in the feedback from networks schools regarding hospitality and support from the hosted school. The experience of teachers at Bun Rany Hun Sen Chakriya Vong Upper Secondary School resulted in dissatisfaction and the staff felt stigmatized when using the secondary resource school. "I feel hesitant to send my students to the secondary resource school when my students and teachers are not warmly welcomed. It is their house and they do not like our house. They are already busy with their students, so they have no time for students from network schools. 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 the whole time. When we asked something, they tended be unhappy to respond to our questions or request." [Pers. Comm. Bun Rany Hun Sen Chakriya Vong USS] By feeling that they were given differential treatment by the host school, network school visitors felt badly when using facilities equipped at the secondary resource schools. In Khmer culture and social norms, people feel something as ownership if it stays under one's authority or management even if it solely belongs to the public. Similarly, people feel guilty when taking advantage of the opportunity to use the secondary resource schools. The final evaluation of EEQP conducted in 2013 also concluded that network schools preferred to have their experiments at their own location. [Pers. Comm. MoEYS]

The research also discovered some limitations in the professional capacity among teachers at host schools and teachers at network schools. The school principal at Chbar Ampeouv Upper Secondary school expressed concern about the capacity of teachers who are using laboratories. "At every meeting or workshop, I always request for capacity-building of the people in charge of the laboratory. The main problem is that the instructions for the equipment are written in a foreign language and there is no translation into Khmer." [Pers. Comm. Chbar Ampeouv USS] In addition, there is not enough equipment for all the students to do practical activities, and so the experience is only available for some of them. When students go to do experiments at the secondary resource schools, some students just go for play because of insufficient equipment. Some other students are not able to comprehend what they are doing due to the lack of a clear explanation. In the past, teachers only drew pictures in order to explain to students about physics. At least, students can now see some demonstration from experiments. [Pers. Comm. Porng Tek LSS] Teachers at host schools are responsible for assisting teachers from network schools to do demonstrations or do experiments with students. Both of them had limited capacity in using the laboratory, especially any newer technology and science. The school principal at Hun Sen Chamkar Dong Upper Secondary School admitted that a lack of expertise to support the secondary resource school remained a key issue. Both teachers at host schools and network schools do not have sufficient skills to use and manage the laboratory effectively.

[Pers. Comm. Hun Sen Chamkar Dong UPP] Similarly, 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 is very limited. While teachers from school networks are not able to use the equipment well, teachers from host schools are not able to provide much assistance. [Pers. Comm. Porng Tek LSS]

> We have sufficient teachers; but, they have limited capacity to use the laboratory. At my school, we do not have human resource to manage laboratory equipment well. So we send teachers and students to the resource school because I expect they will both learned something from the people in charge. But the people in charge at the laboratory 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 the equipment well. They just have a bit more knowledge about experiments than our teachers. [Pers. Comm. Sandech Ov USS]

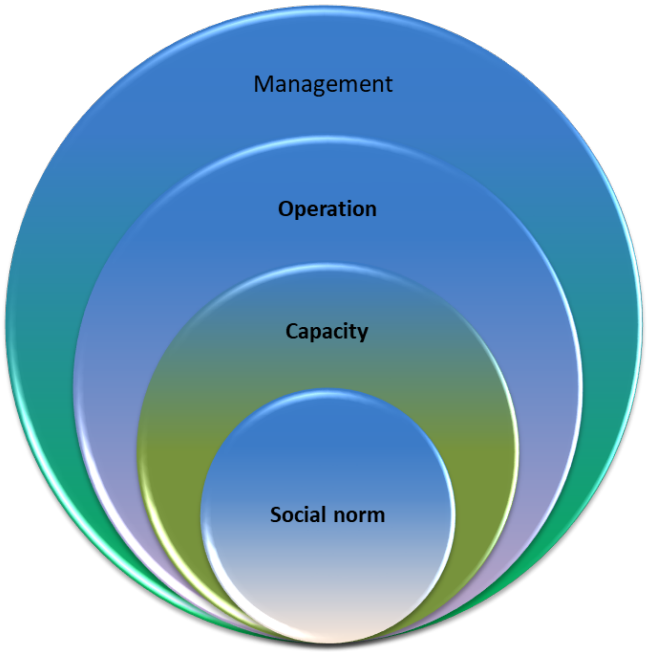

Figure 10: Problems and constraints in managing secondary resource schools

With regard to operations, the budget is not enough for covering the transportation 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. In grade 7 alone, there were more than100 students, but only some of them were provided with the opportunity to do experiments. [Pers. Comm. Tek Thlar LSS] At Sandech Ov Upper Secondary School,

the available budget was able to send students in grades 11 and 12 to the secondary resource schools a few time per year in order to do experiments in the four subject areas of chemistry, biology, physics and earth science. The teachers also did some simple experiments at school because there were insufficient resources to cover the cost of transportation to the secondary resource schools on more occasions. [Pers. Comm. Sandech Ov USS] Teachers and students were complaining about insufficient support for transportation to resource schools. In addition, teachers were found it difficult to manage the transportation of students to the secondary resource school because of the lengthy distance from network schools [Pers. Comm. Porng Tek Lower LSS]. Furthermore, teachers were worried about the high risk to students when traveling individually to the secondary resource schools. The school principal at Damrei Chorn Khlar Upper Secondary School shared his experience: "There are not enough materials and equipment for students and teachers to use 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 were not there. They wasted a lot of our time waiting. I think it is better to allocate funds to each school for doing their own experiments and practice. It is also such a waste of money to spend on transportation and the results from practice and experiments is small. If we do it at our school, we can make better quality experiments and practice." [Pers. Comm. Damrei Chorn Khlar LSS]

Management of the secondary resource school remained a great concern regarding scheduling experiments at SRSs of hosted school and school networks, the complicated procedure for requesting transportation expenditure, hygiene and campus cleanliness, and the quality of the building. According to the Department of Secondary Schools, resource schools have tight schedules so network schools were not able to allocate sufficient time to do experiments and practice. For example, each school network can only propose one hour per year for earth science [Pers. Comm. MoEYS]. In addition, a laboratory could only accommodate between 20 and 30 students. If there were more students, they were sent to the library. In some cases, students were not interested much in the library because their school also had library. [Pers. Comm. Chbar Ampeouv USS] There were many inconvenient experiences faced by network schools when requesting to use the secondary resource school. For example, at Chbar Ampeouv Upper Secondary School, resource schools were always fully booked and it was quite hard to get a respond to the further request for adding the network school to the schedule. This resource school needed more facilities to provide enough services for network schools. [Pers. Comm. Chbar Ampeouv USS] Teachers from network schools found it difficult to arrange the financial statement of expenditures after sending students to

the secondary resource school. [Pers. Comm. Hun Sen Krong Kep LSS]. Moreover, the cleanliness management of the secondary resource school required improvement, such as toilet hygiene. The internal regulation of resource schools was also needs to be strictly enforced. The request form for using the secondary resource schools should be fixed and not changing all the time, as it is wasting the time for learning. [Pers. Comm. Hun Sen Krong Kep LSS] At Hun Sen Balang Upper Secondary School, the building was suddenly broken into after the construction. Some rooms were also broken into. The school contacted the Provincial Department of Land Management Urban Planning and Construction for inspection of this mater. The building is now fine for use. [Pers. Comm. Hun Sen Balang USS]

4. Discussion and policy implication

4.1. Promoting stem education through establishing secondary resource schools

In order to engage more students in learning STEM subjects, they need access to STEM experiment and practice 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 learning STEM subjects. According to the interviews with the Department of Secondary School of MoEYS, the establishment of a laboratory at each school is a long-term process and it requires a very large government budget. At the moment, the MoEYS does not have sufficient budget to establish a laboratory at each school, so the secondary resource schools function as an alternative. Evidence from this research confirms that secondary resource schools do contribute to promoting STEM education in Cambodia. At Hun Sen Chamkar Dong Upper Secondary School, the secondary resource school has been used to host contests and a science exhibition which promoted STEM education. Also, the secondary resource schools are providing preparation and training of the outstanding students for the national competition. In 2019, students from Hun Sen Chamkar Dong Upper Secondary School won third place in the science competition. According to the Department of Secondary Schools of MoEYS, there were 176 students including 71 females at the 50 resource schools who got an 'A' on the national examination for upper secondary school; it accounts 37% of the nation-wide 'A' scores. This achievement clearly demonstrates the increased interest in STEM education by students at the secondary school.

In Cambodia, public schools have restricted access to laboratory for experiment and practice for students and teachers because of (1) dependence on the government budget, and (2) lack of

their own income generation. Without laboratory facilities and equipment, there are few opportunities for students and teachers to engage in science, this lack of access to appropriate material resources restricts scientist's creativity in experimental designs and contributes to a reproducibility crisis as learners struggle to replicate the work of peers. Under USESDP II, some school networks have been granted with a budget for establishing their own laboratory. By doing so, it would not only reduce the burden of the secondary resource schools, but also increase the opportunity for students at the former network schools network to be able to experiment and practice more. However the secondary resource schools remain useful for network schools because facilities and equipment are much more advanced and sufficient. Network schools may consider bringing students to use the secondary resource schools when they require more advanced facilities and equipment. At the same time, other network schools may consider to establish their own simple laboratories for experiment and practice. The schools may start with materials or equipment which can be produced by teachers at the school. As each network school gains its own simple laboratory, the number of visits at the secondary resource schools will gradually be reduced. As a result, the available budget provided for covering the transportation cost to the secondary resource schools can be used for car rental, to improve safety of students and teachers.

Alternatively, the operation of a mobile laboratory in each province across the country could probably help to spread wider access for network schools or even secondary schools in remote areas. These laboratories on wheels would be used for science education to support STEM education at secondary schools. The mobile laboratories would travel to schools and provides the schools with educational resources which they otherwise lack. The mobile laboratories would be staffed by experts which require for students to practice for example physics, chemistry, biology and earth science. The mobile laboratory van is equipped with full-size instruments for an extensive scope of experiment and practice for students at secondary schools. The management of mobile laboratories would be similar to the secondary resource schools, but they would be under the direction of the Provincial Department of Education Youth and Sport. The secondary schools are able to request the mobile laboratory van for one week to stand by at their schools, enabling teachers and experts to 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 accessibility would be more homogenous across the country. In addition, the cost of establishment and operation would be more affordable.

4.2. Determining the appropriate location of the secondary resource schools in Cambodia

The findings of this research clearly confirm that locations of the existing secondary resource schools in Kampong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh are not spatially optimized. The policy by the MoEYS to locate the secondary resource schools establishes the following criteria: (1) the school is located in the center of the province municipality or district (khan); (2) there are both 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 supplies provided for the computer and laboratory location. The criteria that electricity and water utilities are available, is no longer relevant as those services now exist everywhere across the country. In addition, the criteria of location should probably weigh heavier among the five standards. At this time, it is not clear how much weight is given to the different criteria. According to the fieldwork, criteria such as the population of students per school, the availability of experts in the fields of science, and good collaboration between host schools and network schools should also be taken into account.

Furthermore, it is important to apply a feasibility study and spatial analysis when selecting the location of secondary resource schools. A feasibility study helps to collect information about the perception of students and teachers at both the secondary resource schools and network schools. Based on the results, current issues and problems related to social norms, capacities, operations, and management, can probably mitigated. Moreover, Geographical Information Systems (GIS) can be used to identify the most suitable new school location. In addition, the feasibility study and GIS application are useful for planners and project designers to select the locations which most easily accessible by all network schools. In addition, the feasibility study helps to enhance operations, capacity-building and perceptions of host schools and network schools for better management of the secondary resource schools. In general, host schools experience more benefits from the use the secondary resource schools than network schools because of far distance, insufficient transportation funds and experimental equipment, and ineffective schedule management for booking the use of the laboratories.

To identify appropriate locations for secondary resource schools, Phnom Penh and Banteay Meanchey were selected as case studies. The best location for the establishment of secondary resource schools are in Mongkol Borei for Banteay Meanchey as well as Boeng Trabek Upper Secondary School and Santhor Muk Upper Secondary School for Phnom Penh. The selection of these locations for secondary resource schools are considered best because

they would help to increase access by network schools with more affordable transportation cost, less traffic, and more safe travel by students and teachers. In addition, convenient access helps to increase the frequency of visits to the secondary resource schools by network schools. In the future, secondary resource schools should be established in a central location, where there are many lower and upper secondary schools. In order to carry out a sound spatial analysis for determining the appropriate location of secondary resource schools, GIS applications and feasibility studies should be utilized to arrive at decide on the optimal locations.

4.3. Policy implication for the establishment of secondary resource school in Cambodia

After participating in experiments at secondary resource schools, students change in a positive manner because they are able to learn more from real demonstrations. There is no doubt that it is impossible to promote STEM education without laboratories and it is impossible to make laboratories possible at all the lower and upper secondary schools across the country in the near future. As a result, the construction of secondary resource schools is still the best choice. However, there is a need to improve the cooperation between host schools and network schools. In addition, the effectiveness of operations management as well as capacity building of teachers at both host schools and network schools needs to be improved. In order to increase the frequency of visits and the purchase of equipment of the school networks, the budget amount of USD 500 should be increased. In relation to the management of the laboratories, all equipment in each laboratory should be labeled in the Khmer language so that all the teachers and students can understand it. In addition, schedule preparation should be improved in order to increase ease of use of the secondary resource schools. Capacity building should be carried out after a needs assessment is conducted, so that the course would be able to respond to the real needs of the teachers and students.

Alternatively, small-size laboratories constructed at network schools also resolve some of the issue of reducing the burden on secondary resource schools. However, it requires time to build sufficient laboratories across the country, and the current construction efforts gradually helps to reduce the problem. The network schools should also carry out simple experiment and practice at their schools, and, the schools should only come to the secondary resource schools when they require advanced equipment. In some cases, teachers can only perform simple experiments in their own school rooms to help students to associate theories with practice. The operation of mobile laboratory not only extends the accessibility of network schools, but it also

helps to increase the access for schools in remote areas. In comparison to the construction of new secondary resource schools, procuring the usage of a mobile laboratory would be less expensive. In particular, its mobility allows it access to remote locations, and can increase the frequency of access by students across schools.

5. Conclusion

Based on the findings of surveys conducted in Kampong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh, , it can be concluded that the establishment of secondary resource schools in the 25 provinces and cities has contributed to the promotion of STEM education in Cambodia. The secondary resource schools are providing students with opportunities to do experiments and practice in the fields of physics, chemistry, biology and earth science. However, the gap between host schools and network schools was large because host schools already enjoyed all the benefits of the secondary resource schools. Network schools were confronted with obstacles that resulted from of insufficient transportation funds, limited capacity of teachers at the host schools and network schools, and weak operation and management at the host schools. Since 2004, the ADB has funded the establishment of secondary resource schools through three different projects, they include the ESDP II, the EEQP, and the USESDP. Today, 50 secondary resource schools have been instituted throughout Cambodia.

On average, there are 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 to the number of network schools. In order to operate the secondary resource schools and network schools, the ADB and the MoEYS are also providing them with an annual budget for operations of the resource school, transportation, the purchase of materials purchase, and a scholarship scheme for poor students. The average distance between secondary resource school and network schools was 4.2 kilometers, with distances ranging from 2.0 to 9.4 kilometers. Comparatively, Kratie had the furthest average distance and Banteay Meanchey had the nearest. Due to limits on the government budget, it will be quite challenging for Cambodia the construction of equipped laboratory facilities for experiments at all secondary schools in Cambodia in the next 10 years.

As an example, Banteay Meanchey and in Phnom Penh were selected as case studies to explore the question of how to identify the appropriate location for secondary resource schools.

In the future, the establishment of secondary resource schools can be done at Samdach Ov or Serey Sophoan Upper Secondary Schools. In Phnom Penh, Santhor Muk Upper Secondary School or Boeng Trabek Upper Secondary School are likely to optimize the distance between network schools. In managing the secondary resource schools, four key problems were found; they included social norm, capacity, operation, and management. While, network schools felt less hospitality, host schools faced challenges stemming from operation on small annual budget, management of schedules, and service to support network schools. In particular, host schools and network schools did not have sufficient capacity in using the 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 School	October 2019
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 Kampong Thom	Provincial Department of Education Youth and Sport in Kampong Thom	November 2019
Stung Sen USS	Stung Sen Upper Secondary School	November 2019
Panha Chi LSS	Panha Chi Lower Secondary School	November 2019

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