កាលិកបត្រស្រាវជ្រាវមនុស្សសាស្ត្រនិងវិទ្យាសាស្ត្រសង្គម

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Challenges and Solutions to Teaching and Learning Science at Upper Secondary School in Cambodia

បញ្ហាប្រឈមនិងដំណោះស្រាយចំពោះការបង្រៀននិងរៀនមុខវិជ្ជាវិទ្យាសាស្ត្រនៅថ្នាក់មធ្យមសិក្សាទុតិយភូមិនៅកម្ពុជា

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ABSTRACT

This study aimed to assess the current situation of human resources and school facilities to support teaching and learning science in Cambodian public high schools. This study surveyed 240 science teachers and 45 principals. The data analysis employed descriptive statistics such as mean, standard deviation and percentage, and inferential statistics such as t-test, One-Way ANOVA, and Chi-Square to examine the association of some demographic variables, including gender, school type and location. The results revealed that Cambodian high schools have suitable infrastructure, incorporating libraries, science-laboratory rooms, computer labs, internet connection, clean water, toilet and electricity. However, ordinary high schools lack laboratory materials and computers for students to learn and use to support their learning. The insufficient number of classrooms and science teachers leads to a large class size and a high student-to-teacher ratio. Cambodian high school science teachers had sufficient knowledge in their subject content matter and pedagogical skills to teach the subjects. However, they did not indicate strong confidence in being an expert in their major. Cambodian high school science teachers possessed sufficient knowledge of basic ICT regarding administration work, social communication, and professional development. They have trivial knowledge of advanced ICT and did not indicate the effective use of ICT. The Ministry of Education, Youth and Sport of Cambodia should put more effort and investment into enhancing effective schools for science education and developing a comprehensive science teacher education program to produce effective teachers who can adopt ICT to teach science subjects effectively.

KEYWORDS: effective school, effective teaching, science education, science teachers, Cambodia

សង្ខិត្តន័យ

ការសិក្សានេះមានគោលបំណងវាយតម្លៃស្ថានភាពបច្ចុប្បន្ននៃធនធានមនុស្ស និងបរិក្ខារសាលារៀនដែលជួយសម្រួលដល់ការបង្រៀននិងរៀនមុខវិជ្ជាវិទ្យាសាស្ត្រនៅថ្នាក់មធ្យមសិក្សាទុតិយភូមិនៅកម្ពុជា។ ការសិក្សានេះបានធ្វើការស្ទង់មតិគ្រូបង្រៀនមុខវិជ្ជាវិទ្យាសាស្ត្រចំនួន 240 នាក់ និងនាយកសាលាចំនួន 45 នាក់។ ការវិភាគទិន្នន័យធ្វើឡើងដោយប្រើប្រាស់វិធីស្ថិតិពណ៌នាដោយបង្ហាញលទ្ធផលជា តម្លៃមធ្យម គម្លាតស្តង់ដារ និងភាគរយជាដើម។ ទិន្នន័យត្រូវបានវិភាគដោយប្រើប្រាស់វិធីស្ថិតិសន្និដ្ឋានដូចជា t-test, One-Way ANOVA និង Chi-Square ដើម្បីពិនិត្យមើលការទំនាក់ទំនងរវាងអថេរប្រជាសាស្ត្រមួយចំនួនដូចភេទ ប្រភេទសាលារៀន និងទីតាំង។ លទ្ធផលបានបង្ហាញថា វិទ្យាល័យនៅក្នុងប្រទេសកម្ពុជាមានហេដ្ឋារចនាសម្ព័ន្ធសមស្រប ដោយមានបណ្ណាល័យ មន្ទីរពិសោធន៍វិទ្យាសាស្ត្រ បន្ទប់ពិសោធន៍កុំព្យូទ័រ បណ្តាញអ៊ីនធើណិត ទឹកស្អាត បង្គន់អនាម័យ និងអគ្គិសនីសម្រាប់ប្រើប្រាស់។ ក៏ប៉ុន្តែ វិទ្យាល័យធម្មតាមានការខ្វះសម្ភារៈមន្ទីរពិសោធន៍ និងកុំព្យូទ័រសម្រាប់សិស្សរៀន និងប្រើប្រាស់សម្រាប់ទ្រទ្រង់ការសិក្សារបស់ពួកគេ។ ចំនួនថ្នាក់រៀន និងគ្រូបង្រៀនមុខវិជ្ជាវិទ្យាសាស្ត្រមានចំនួនមិនគ្រប់គ្រាន់នាំឱ្យមានចំនួនសិស្សច្រើនក្នុងមួយថ្នាក់ៗ និងសមាមាត្រសិស្សគ្រូខ្ពស់។ គ្រូបង្រៀនវិទ្យាសាស្ត្រនៅវិទ្យាល័យនៅកម្ពុជាមានចំណេះដឹងគ្រប់គ្រាន់លើខ្លឹមសារមុខវិជ្ជាឯកទេសរបស់ពួកគេ និងជំនាញគរុកោសល្យសម្រាប់បង្រៀនលើមុខវិជ្ជាឯកទេសនោះ។ លទ្ធផលក៏បង្ហាញថាគ្រូបង្រៀនវិទ្យាសាស្ត្រថ្នាក់វិទ្យាល័យនៅកម្ពុជាមានចំណេះដឹងគ្រប់គ្រាន់លើបច្ចេកវិទ្យាព័ត៌មាន និងទំនាក់ទំនង(ICT) ជាមូលដ្ឋានទាក់ទងនឹងការងាររដ្ឋបាល ទំនាក់ទំនងសង្គម និងការអភិវឌ្ឍន៍វិជ្ជាជីវៈ។ ពួកគេមានចំណេះដឹងតិចតួចអំពីបច្ចេកវិទ្យាព័ត៌មានកម្រិតខ្ពស់ និងមិនអាចប្រើប្រាស់ជំនាញបច្ចេកវិទ្យាព័ត៌មានក្នុងការបង្រៀនឱ្យមានប្រសិទ្ធភាពនោះទេ។ ក្រសួងអប់រំ យុវជន និងកីឡាកម្ពុជាគួរខិតខំប្រឹងប្រែង និងវិនិយោគបន្ថែមទៀតក្នុងការលើកកម្ពស់សាលារៀនប្រកបដោយប្រសិទ្ធភាពសម្រាប់ការអប់រំមុខវិជ្ជាវិទ្យាសាស្ត្រ និងបង្កើតកម្មវិធីអប់រំគ្រូបង្រៀនវិទ្យាសាស្ត្រឱ្យបានគ្រប់ជ្រុងជ្រោយ ដើម្បីផលិតគ្រូបង្រៀនប្រកបសមត្ថភាព អាចប្រើប្រាស់បច្ចេកវិទ្យាព័ត៌មានផ្សេងៗ ដើម្បីបង្រៀនមុខវិជ្ជាវិទ្យាសាស្ត្ររបស់ខ្លួនប្រកបដោយប្រសិទ្ធភាព។

ពាក្យគន្លឹះ: ប្រសិទ្ធភាពសាលារៀន, ប្រសិទ្ធភាពការបង្រៀន, ការអប់រំវិទ្យាសាស្ត្រ, គ្រូបង្រៀនវិទ្យាសាស្ត្រ, កម្ពុជា

1. INTRODUCTION

Cambodia is one of the countries with the fast economic growth in the world. Her economy has sustained an average growth rate of 7.7 per cent between 1998 and 2019 (World Bank, 2021). To keep growing at this high pace, Cambodia needs thousands of engineers and technicians (Khieng, Srinivasa, & Chhem, 2015). Cambodia has become a lower-middle-income country since 2015 and is aspiring to become an upper-middle-income country in 2030 (World Bank, 2021). Science has become a part of the prioritized agendas to promote the economic and social development of the country as specified in the Cambodia Industrial Development Policy 2015-2025 (Royal Government of Cambodia, 2015).

Aligning with the ambition of the Royal Government of Cambodia, the Ministry of Education, Youth and Sport (MoEYS) has made great efforts to reform the education system to promote education in general and science in particular by supporting and implementing the tracking education system at high school since 2010, directing students towards either the science track or the social science track, developing the secondary resource centres (SRCs) in 2011, reforming the national exam from 2014, promoting STEM (Science, Technology, Engineering and Mathematics) education and New Generation School (NGS) policies in 2016, as well as increasing teacher salary. These boil down to the logic that Cambodia needs science and science-related workforces and citizens to serve the labour markets and its economic goal and to be capable of being lifelong learners at a higher level of education or her workplace.

On the other hand, the efforts made by the MoEYS have not made significant improvements yet. Cambodian students have still performed low in science. The National Assessment 2018 showed only 20% of Cambodian 11th-grade students achieved a basic level or higher in Physics (MoEYS, 2019b). Similarly, the results of the Program for International Student Assessment for Development (PISA-D) showed only 5% of the 15-year-old students (equivalent to high school grade 10) attained merely a minimum proficiency level (i.e., level 2 of the 6 PISA proficiency levels) in science. Teaching quality was argued as the main factor accounting for low achievement (MoEYS, 2018).

School facilities were also a concerning topic while addressing teaching and learning quality. Cambodian school infrastructure has been seen as relatively poor and under-resourced, even worse in rural areas (MoEYS, 2018) and has slowly been developed. Nationwide, there are 741 high schools, of which 75% are public schools. Most public schools (i.e., 74%) are in rural areas (MoEYS, 2021). Beginning with the Education Sector Development Project 2 (ESDP2), launched in 2011, eighteen public schools were converted to SRCs consisting of two science labs, two computer labs with internet services, an e-library and a large seminar room. Followed by three other projects for a decade, the number has increased to as many as 67 schools in total, equivalent to about 12%. In addition, the functioning of SRCs has been under-investigated and under-improved due to the insufficient operation budget and low teacher competency in laboratory skills. As part of the educational reform in 2014, New Generation Schools (NGS) were established with better facilities. As for 2023, there are 6 (less than 1%) NGS high schools in Cambodia.

Regarding ICT for Education, the Education for All National Plan 2003-2015 was an unprecedented official document of Cambodia that mentioned ICT policy in Cambodian education. Since then, significant strategic policies, plans, projects and programs have been documented and implemented concerning ICT in education. One of the specific goals is to enhance the quality of teaching and learning through ICT integration. Although much effort has been made over these last two decades, ICT usage in teaching and learning remains limited (MoEYS, 2019a), as can be seen in the baseline statistics of the Education Strategic Plan (2019-2023) showing only five per cent of upper secondary schools used ICT as a supporting tool in teaching and learning. Fortunately, enormous efforts and investments in distance learning during the COVID-19 outbreak have fostered digital transformation and proliferated ICT in education in Cambodia (Heng, 2021; Thy, Ly, & Ean, 2023). However, the current situation (i.e., after the re-opening of the schools) of ICT facilities and usage in high schools remains uncovered.

Furthermore, science subjects have gradually been losing their popularity among high school students. The number of student enrolments in the science track dramatically dropped from around 94% in 2014 to about 39% in 2019. On average, about 54% of those who chose the science track passed the National Grade 12 Exam between 2015 and 2019 (Ing, 2019). This trend seems to be reversed to what MoEYS intended to attain despite MoEYS's efforts. These rationales motivate the authors to conduct this study to understand the current situation of science education in Cambodia. The present study aims to determine the challenges facing teaching and learning in science at upper secondary education in Cambodia, centring around human and infrastructure resources and propose appropriate improvement solutions. Therefore, this study seeks to answer two questions:

- Does the current situation of human and infrastructure resources in schools facilitate teaching and learning science in Cambodia?
- How do Cambodian high school science teachers perceive their knowledge and skills about the subject matter, and ICT to teach their subject?

2. LITERATURE REVIEW

The quality of teachers defines the quality of education. Teachers and their role are central to discussion among education policymakers (Hanushek & Rivkin, 2006). The quality of teachers can be measured by effective teaching (ET), which is the most outweighing determinant of student learning in the classroom (Sanders & Rivers, 1996). ET requires good teaching that requires teachers to have strong background knowledge of the subject matter: their content knowledge (CK) and pedagogical content knowledge (PCK) (Kleickmann et al., 2013). While CK represents teachers' understanding of the subject matter, PCK is the knowledge needed to make the subject matter accessible to students (Shulman, 1986). This knowledge is the key component of teacher competence that supports teachers' instructional practice as well as student learning (Kleickmann et al., 2013).

In addition, the world today is in the industrial revolution 4.0 period, where the rapid advancement of ICT affects all aspects of society, and education is not an exception. Knowing the subject matter would not be enough for a teacher. Teachers should know about ICT and be able to utilise it to improve teaching and enhance student learning (Noor-Ul-Amin, 2013). Particularly for science subjects, ICT interventions can be used to enhance the practical investigation (i.e., ICT-based experiment) or as a virtual alternative to real practical work (i.e., simulation) (McFarlane & Sakellariou, 2002; Smetana & Bell, 2012). Therefore, knowledge about ICT should also be considered an essential criterion for being a qualified science teacher in the current era and future.

On the other hand, the subject matter, pedagogy, and ICT knowledge are regarded as internal factors of teachers. Several external factors also contribute to ET. While teaching and learning require the existence of teacher and student, the teacher-student interaction is the most critical to ET (Koc & Celik, 2015). Two factors that affect teacher-student interaction in the school are class size (the number of students per class) and student-to-teacher ratio. When class size is big, students are less likely to interact with teachers and vice versa. There is less teaching on a one-to-one basis. Teachers have less time to focus on students, while students have less time to actively attend teacher activities during class (Mishel et al., 2002; Schanzenbach, 2014). This is in a similar vein to the student-to-teacher ratio. Class size and student-to-teacher ratio are generally associated with each other, sometimes considered the same. They both are strongly associated with the number of classrooms and teaching staff available in the schools; however, they are different. Even though the class size is small, the student-to-teacher ratio can still be high, depending on how many classes a teacher is responsible for.

Besides, school facilities such as science laboratories, computer labs and Internet connection, library, clean water and sanitation, and electricity are essential and indirectly and directly contribute to an effective school (Murillo & Román, 2011). Science laboratories allow teachers and students to do various laboratory activities as part of the teaching and learning process. The laboratory has become a distinctive feature of science education (Hofstein, 2017). Science laboratories directly affect students' attitudes and academic performance as per the instructional theory of learning interaction (Pareek, 2019).

The computer is a prominent ICT tool and is becoming increasingly more effective in supporting secondary education (Murillo & Román, 2011). A computer with an internet connection enables students to explore, create, connect, and build digital literacy. The students can access real-time and up-to-date knowledge (e.g., new scientific discoveries) and resources such as science simulation software and videos. In this regard, schools should have computer labs with internet connection for students, especially in developing countries where most students cannot afford a computer. More importantly, the effectiveness is associated with the student-to-computer ratio, where the fewer the ratio, the better (Murillo & Román, 2011).

Libraries have also served crucial roles in teaching and learning. Fundamentally, a library is an organized set of resources, which includes human services as well as the entire spectrum of media (e.g., text, video, hypermedia) (Marchionini & Maurer, 1995). These resources have their role to support and improve teaching and learning (Kuhlthau, 2010; Murillo & Román, 2011). Williams et al. (2013) studied the impact of the school library on learning. The results revealed that school library is an attribute to improving academic attainment, successful curriculum or learning outcomes and positive attitude towards learning.

Electricity is crucial for everyday school operations, including lighting and powering all electrical and electronic devices to support administration things and the teaching and learning process. Last but least, water and sanitation are unarguably important indicators for an effective school. Poor availability and access to water and sanitation are major health concerns and constitute a principal barrier to quality education in schools and narrowing the gender gap in education (Jewitt & Ryley, 2014; Sommer, 2010). Agol & Harvey (2018) reported that the lack of toilets and water sources puts girls at a higher risk of dropping out of school than boys. Poor water and sanitation particularly emphasized the challenges of girls in managing their menstrual hygiene (Jewitt & Ryley, 2014).

Profile of Cambodian Public High Schools

There are three types of public high schools in Cambodia, including Ordinary High Schools (OHS), Secondary Resource Schools (SRS) and New Generation Schools (NGS). OHS and SRS are non-autonomous schools that fixedly follow the Cambodian national curriculum. Teachers and staff are assigned by the Ministry of Education, Youth and Sport (MoEYS). OHS have a relatively poorer infrastructure, which generally lacks science laboratories and computer labs. SRS have a better infrastructure with a resource building that consists of two science labs, two computer labs with internet services, an e-library and a large seminar room. In addition, SRS receive extra budget and technical support for teacher professional development. NGS are semi-autonomous and can generate some income in addition to government subsidy, modify the curriculum to suit their context and recruit teachers and staff as needed and wanted. NGS are richer in infrastructure, especially related to ICT. Every teacher receives a laptop computer, a monthly bonus on top of the state salary and technical support from a local non-government organization (NGO). Therefore, although all three schools are public schools incorporating the same prototype, they practically have different conditions, e.g., receiving support differently, technically and financially.

3. METHODOLOGY

3.1. Research Sample

The selection of participants followed three steps of the sampling process, as the following. Firstly, the researchers purposively selected one province from each of the four regions of Cambodia (the Tonle Sap, the coastal and sea, the central plain, and the mountain) and the capital city. Due to the budget constraint, only one best province that represented the uniqueness of its region was selected. Therefore, the researcher decided to do it purposively. In addition, the capital city was in the central plain; however, its characteristic was far different from other provinces in the same region. Secondly, four high schools from each chosen province, with the criteria of being two urban schools and two rural schools, were purposively and conveniently selected, whereas, for the capital, two downtown and two suburban schools. Thirdly, the selection of teachers and school principals followed a convenient sampling method, where all approachable science teachers in each selected school, during administering the survey, were requested to participate in this study. It is worth noting that the procedure was trying to collectively cover the characteristics of the sample as much as possible, aiming to have a representative sample of the population. When the sample size required was small, together with the complicated nature of Cambodia's geography, employing a random selection method cannot guarantee that all these characteristics are included proportionally in the current study. This study's participants were 285, of which 240 were teachers and 45 were principals and vice-principals.

3.2. Research Instrument

The study employed a survey research method. There were two questionnaires used to collect data: the principal questionnaire and the teacher questionnaire. All were developed by researchers and consisted of two sections.

- The principal questionnaire had 21 questions in total, asking about demographic information, school facilities and statistics of students and teachers.
- The teacher questionnaire had two sections. The first section has 9 questions about demographic information and access to ICT, and 4 questions for school infrastructure assessment, asking the teacher to rate the science-laboratory rooms[1], the sufficiency of material recourse for teaching and learning, the library, and the toilet between 0 to 10, ranking from very bad (0 score) to very good (10 scores). The second section has 11 Likert-type items asking about teachers' knowledge of their subject matter, pedagogy and ICT. Thirteen items were adopted from the work of De Freitas (2018) and modified to suit the Cambodian context, and five items were developed by the researchers. The thirteen items are 5 point-scale items (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

The instruments were reviewed and approved by a team of science teacher educators and members of the Commission of Research Development and Innovation of the National Institute of Education (NIE) in Cambodia for content validity.

3.3. Data Collection and Analysis

Teachers filled out the questionnaire, while the principal and vice-principals were interviewed (i.e., interview survey method). The raw data collected from the questionnaire were entered into a Microsoft Excel spreadsheet and cleaned. The data analyses were performed using the Statistical Package for the Social Sciences (SPSS v.25). The data analysis employed descriptive statistics such as mean, standard deviation and percentage, and inferential statistics such as t-test and One-Way ANOVA, Chi-Square to examine the association of some demographic variables, including gender, school type and location.

4. RESEARCH FINDINGS

Descriptive Statistics

The total number of teachers who participated in this study was 240, of which 44.6% were females, with an average age of 40.4 ($SD = 8.15$), and 11.8 years ($SD = 8.99$) of teaching experience. Most teachers are holding a bachelor's degree (80.0%) followed by a master's degree or higher (14.6%). The number of principals was 45, and 26.7% were females.

Table 1
Number of participants by qualification

	Teachers No. (%)	Principals No. (%)
12+2	11 (4.60)	0 (0)
Bachelor	192 (80.0)	26 (57.8)
Master or higher	35 (14.6)	18 (40.0)
Other	2 (0.80)	1 (2.20)
Total	240 (100)	45 (100)

The average age was 48.62 ($SD = 7.30$) with about 9.52 ($SD = 5.27$) of experience as a principal. About fifty-eight per cent of the principals hold a bachelor's degree and 40.0% hold a master's degree or higher (Table 1).

Research Question 1: Does the current situation of human and infrastructure resources in schools facilitate teaching and learning science in Cambodia?

School Facilities

School principal's data illustrated that all schools have a library and toilets, 78.9% have science-laboratory rooms, and 78.9% possess computer labs. Internet connection is available in all of the schools, and about 95% of schools have access to electricity and clean water.

[1] Authors use science-laboratory rooms instead of science laboratories because most schools in Cambodia reserve a few rooms for laboratories based on Cambodian school standards, and they are generally just empty rooms.

Teachers were asked to evaluate the science-laboratory rooms, the sufficiency of material resources for teaching and learning, the library, and the toilet. The results were summarized in Table 2. Overall, teachers rated 4.90 for the science-laboratory rooms, 4.85 for the sufficiency of laboratory materials, 7.27 for the library, and 6.10 for the toilet. This assessment showed the scores were relatively high for the library and moderate for the toilet assessments, while the scores were relatively low for the science-laboratory rooms and the sufficiency of laboratory materials, and there are big gaps between schools. NGS received up to 8 points, while SRS was 5.52 points and 3.38 points for OHS. Moreover, schools in the capital were rated over the average (6.04), while the schools in other locations were below average, 4.73 and 4.03 for urban and rural, respectively. The overall student-to-room ratio was 44.2. However, the numbers varied greatly due to school locations (Table 3). The ratio in schools in the capital was up to 77.1. This shows that the schools in the capital were lacking rooms for usage as classroom.

Table 2

Assessments of the laboratory, material resource, library and toilet by school types and school locations

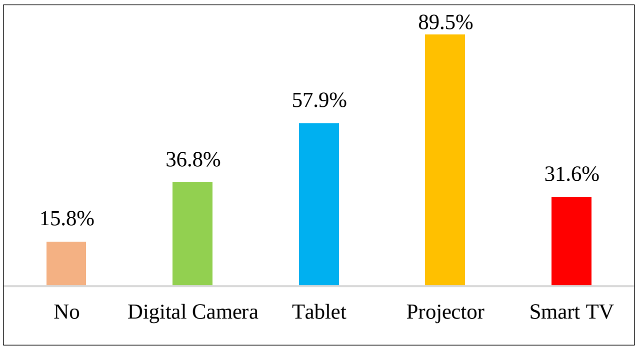
	Laboratory Rate Mean (SD)	Material Resources Rate Mean (SD)	Library Rate Mean (SD)	Toilet Rate Mean (SD)
		School Types		
NGS	8.04 (2.01)	8.00 (1.91)	7.14 (1.65)	6.60 (2.33)
SRS	5.52 (2.69)	5.25 (2.84)	7.03 (1.89)	6.00 (2.54)
OHS	3.38 (3.06)	3.58 (2.98)	7.61 (1.82)	6.09 (3.22)
P-value	**< .000**	**< .000**	.102	.596
		School Locations		
Capital	6.04 (3.23)	5.96 (3.46)	6.81 (1.71)	6.46 (2.53)
Urban	4.73 (3.09)	4.66 (2.98)	7.19 (1.88)	6.12 (2.85)
Rural	4.03 (2.90)	4.11 (2.82)	8.33 (1.54)	5.50 (3.04)
P-value	***.007***	***.011***	***.002***	.294

Similarly, the student-to-classroom ratio was 43.4. The number of students per class was not statistically significantly different due to region. For schools in the capital, especially, the number of students per class was about 50.4. This indicated that the schools in the capital implemented a shift system (i.e., morning-shift and afternoon-shift classes). However, the number differed due to school types (Table 3). NGS was significantly the lowest ratio (*Mean 33.4, SD = 0.59*).

On the other hand, the student-to-computer ratio was 55.0. The numbers were spread extensively across school types (Table 3). NGS have the least ratio (15.1), whereas ordinary high schools (OHS) have the highest ratio (70.0). Schools also have some other electronic devices other than the computer, including projectors, smart TVs, tablets and digital cameras, in which about 90% of schools have projectors and about 60% have tablets to serve for teaching and learning, while, about 16% of schools have no extra electronic device (Figure 1).

Figure 1

Other electronic devices available in schools



Teacher and Staff

Overall, 53.8% of the teachers own a computer, 12.1% own a tablet, and 96.3% own a smartphone. Figure 2 shows percentages of teachers who own these devices and access to the Internet categorized by type of school. Regarding computer availability, around 90% of NGS teachers own a computer, while about 50% of SRS and OHS teachers do. In addition, more than 95% of the teachers had a smartphone and 94.2% had access to the Internet. On average, the student-to-staff ratio was 17.4, and the student-to-teacher ratio was 20.5. This situation was not different for all school types and locations (Table 3).

Figure 2

Percentage of teachers owning electronic devices and access to the Internet by school type

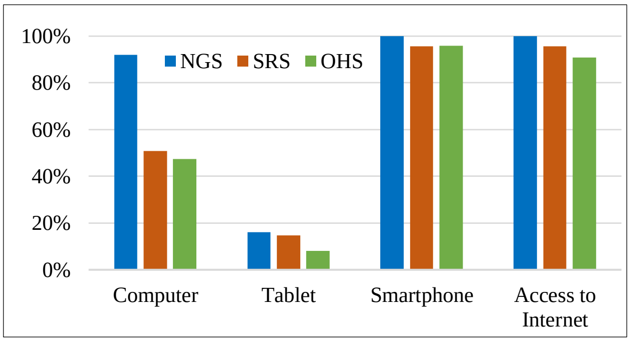


Table 3

Ratios of students to teacher, room, classroom and computer by school types and school locations

	Student-to-Staff Ratio Mean (SD)	Student-to-Teacher Ratio Mean (SD)	Student-to-Room Ratio Mean (SD)	Student-to-Classroom Ratio Mean (SD)	Student-to-Computer Ratio Mean (SD)
			School Types		
NGS	14.0 (1.47)	17.9 (3.42)	34.8 (12.8)	33.5 (0.59)	15.1 (6.32)
SRS	18.2 (7.51)	22.3 (7.17)	42.3 (23.9)	44.4 (7.42)	57.5 (34.8)
OHS	17.8 (3.82)	20.1 (4.09)	47.7 (21.9)	45.2 (11.8)	70.0 (39.0)
p-value	*.098*	*.193*	*.403*	***.036***	***.026***
			School Locations		
Capital	18.6 (4.00)	21.3 (3.88)	77.1 (30.0)	50.4 (22.7)	53.1 (64.7)
Urban	16.1 (5.92)	19.4 (5.86)	35.6 (12.3)	40.6 (5.27)	39.5 (22.3)
Rural	20.1 (3.60)	23.0 (4.09)	44.2 (13.8)	45.8 (5.06)	79.8 (51.0)
p-value	*.063*	*.081*	***.005***	*.323*	*.216*

Research Question 2: How do Cambodian high school science teachers perceive their knowledge and skills about the subject matter, and ICT to teach their subject?

About 72.5% of teachers stated that they have sufficient knowledge about their subject matter. About 44.6% considered themselves an expert in their major. About 69% of teachers confessed that they had pedagogical knowledge and skills to help students better understand the content of their subject matter. The results showed no statistical difference among gender, school type and school location.

Regarding knowledge and skills in ICT, the data shows that 59.6% of the teachers affirmed that they knew how to use social media such as Facebook, YouTube, Telegram, etc., and 54.2% knew how to use online conferencing tools such as Zoom, Google Meet, Microsoft Teams, etc. And about half of the teachers believed that they could update their knowledge and skills in their field from various sources on the Internet. However, only one-third of the teachers said they knew about different ICT technologies that could be used to teach the content in their subject. Less than one-fourth felt confident in using online learning platforms (e.g., Google Classroom, Seesaw, Moodle) to give lessons to their students. There is no statistical evidence of association with gender, school type, and school location either found.

When asked about the effective use of computers, only 21.3% of teachers believed they could do it. In this case, in particular, NGS showed a significantly higher percentage of agreement, 60%, while the other two schools were pretty low, 15.5% for SRS and 18.2% for OHS (χ^2 *(4, N = 240) = 29.58, p < .000*).

For knowledge in advanced ICT, 21.3% of teachers confirmed knowing how to create and publish web pages, and only 3.3% said they understand computer programming and know how to code. The results also showed no statistical difference among gender, school type, and school location.

5. DISCUSSION

The class size in Cambodia is pretty big, on average about twice as many as in European or OECD countries (about 20 students per class) (OECD, 2023). Such a big class size can lead to less teacher effectiveness or quality of teaching and learning (Akerhielm, 1995; Koc & Celik, 2015; Schanzenbach, 2014). Literature could not give a clear-cut. The class

Table 4

Percentage of teachers rated on survey items

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am confident that I have sufficient knowledge about my subject.	1.3%	5.8%	20.4%	44.6%	27.9%
I consider myself an expert in my subject.	2.5%	16.7%	36.3%	33.8%	10.8%
I use a variety of teaching strategies to help my students better understand the content of my subject.	1.3%	6.7%	23.3%	47.1%	21.7%
I know how to use social media (e.g., Facebook, YouTube, Telegram, etc.).	2.5%	14.6%	23.3%	36.3%	23.3%
I know how to use conferencing tools (e.g., Zoom, Google Meet, Microsoft Teams, etc.).	5.0%	13.8%	27.1%	30.4%	23.8%
I can update my knowledge and skills in my subject from various sources on the Internet.	4.2%	17.5%	30.8%	35.8%	11.7%
I know about different ICT technologies that I can use to teach the content in my subject.	11.3%	23.8%	31.7%	27.5%	5.8%
I am confident to use online learning platforms (e.g., Google Classroom, Seesaw, Moodle, etc.) to give lessons to my students.	12.5%	30.4%	33.3%	16.3%	7.5%
I have the technological skills to use computers effectively.	17.1%	28.8%	32.9%	16.7%	4.6%
I know how to create and publish web pages.	20.8%	33.8%	24.2%	15.0%	6.3%
I understand computer programming and know how to code.	60.4%	23.8%	12.5%	2.1%	1.3%

size in Cambodia is pretty big, on average about twice as many as in European or OECD countries (about 20 students per class) (OECD, 2023). Such a big class size can lead to less teacher effectiveness or quality of teaching and learning (Akerhielm, 1995; Koc & Celik, 2015; Schanzenbach, 2014). Literature could not give a clear-cut conclusion on class size and outcome relationship (Akerhielm, 1995); however, there was an agreement that reducing class size could lead to student-centred teaching, more individualized instruction, fewer disruptions and less student misbehaviour (Hattie, 2005). Reducing class size can help to enhance teaching and learning (Schanzenbach, 2014) but is a very costly decision, and the size effect is rather small, about 0.1-0.2, compared to other educational interventions (Hattie, 2005). According to Smith & Glass (1980), 10-15 students, at least below 20, per class is regarded as reasonably small. In this sense, it would be challenging for a least developed country like Cambodia.

The student-to-teacher ratio of Cambodian high schools remains high compared to European and OECD countries. While only 12 and 13 in European and OECD countries, respectively (OECD, 2023), Cambodia is about 1.7 times bigger. This should be another concern for Cambodia. Koc & Celik (2015) argued that the effectiveness of teachers depended on teacher-student interaction and this interaction heavily depended on the number of students per teacher (i.e., student-to-teacher ratio), not directly on class size. In their study 'The Impact of Number of Students per Teacher on Student Achievement', Koc & Celik (2015) found a moderate negative correlation between the student-teacher ratio and achievement.

The pivot of class size and student-to-teacher ratio discussions toward effective teaching or learning outcome is student-teacher interaction. Class size indicates student-teacher interaction during classes, whereas student-to-teacher ratio is overall. Learning does not happen only during but also before and after the classes. If the teacher's schedule is not tight, they have time for students and help them learn. In this sense, the solution should be that hiring more teachers is more cost-effective than constructing more school buildings aiming at reducing class size, particularly for developing countries like Cambodia, where the annual budget for education is limited. However, this solution may not apply to the schools in the capital city of Phnom Penh, where the scarcity of classrooms is about double compared to the other areas. Furthermore, the traditional practice of the shift system should be greatly reduced or discontinued because lots of curriculum time is lost annually (Dawson, 2010). MoEYS should consider building extra buildings in existing schools and, if possible, opening new high schools to share the exceeding number of students from existing high schools. Besides, the school principal should consider grouping students who share a similar manner which is beneficial from a class size (Akerhielm, 1995) and assign appropriate teachers to such a class. Teachers should be aware of and apply the concept of excellence in teaching for different class sizes (Hattie, 2005).

Science laboratories have played important roles in science education (Hofstein, 2017). They enhance the science teaching and learning process and affect students' attitudes and academic performance in science (Pareek, 2019). However, Cambodia seems to move slowly on this. Overall, Cambodian high school science laboratories are still in bad condition, particularly for OHS, which is the same as what has been reported by Set (2016) and Mam (2021). Cambodia needs more political and financial commitment from MoEYS or the Royal Government of Cambodia to improve this situation.

Educational technologies in the classroom become increasingly necessary and the computer is the primary tool. Computer technologies can transform traditional into state-of-the-art teaching and learning by accessing information to explore new knowledge and allowing teachers and students to interact with peers and experts and express and communicate beyond classroom walls (Songer, 2007). Word processing, spreadsheet, and presentation software have facilitated text preparation and printing freely as wanted. For science classes, computer simulations present theoretical or simplified models of real-world components, phenomena, or processes, including animations, visualizations and interactive laboratories' (McFarlane & Sakellariou, 2002; Smetana & Bell, 2012). Believing in such advantages, many countries around the globe keeps trying to reduce the student-to-computer ratio to 1 (one computer for one student). Japan, for example, through the GIGA (Global and Innovation Gateway for All) School program by March 2024, every pupil will have one terminal (a PC or a tablet) with high-speed and secure Internet for their learning at school (The Japan Times, 2021). In some advanced economy countries such as Luxembourg, the United Kingdom, the United States, New Zealand, Australia etc., the student-to-teacher ratio has already been smaller than one, where the OECD average is about 1.25 (OECD, 2020). Sadly, in Cambodia, the ratio is extremely high (55), even compared to its neighbouring countries like Thailand (1.25) and Vietnam (4) (OECD, 2020). More effort and investment are required for Cambodia to reduce the number and to catch up with neighbouring countries in the region. In the meantime, schools may organise schedules for students to access school computers with a clear purpose (i.e., for learning or support learning). It may also be possible that schools offer priority to only students of senior level rather than all students. Therefore, the schools could optimise this shortage of resources. Research evidenced that just one hour per day of using a computer could significantly improve student reading and mathematics performance (Lee et al., 2009).

The findings showed teachers had enough knowledge of their subject content matter and pedagogical skills to teach their subjects. According to Shulman (1986), teaching is a complex process that needs to emerge between subject content knowledge and general pedagogy. These two are the primary elements for teachers to design effective teaching and learning models and are widely accepted as teacher knowledge (Berry et al., 2016). Teaching quality relies on teachers' subject content knowledge and pedagogical skills to facilitate effective teaching and promote a fruitful learning experience for students (McNamara, 1991). Further-more, teachers of a subject should be an expert in that subject. An expert teacher is a master of their subject matter and sensitive to diverse ways of how student learn their subject, and flexible to adapt appropriate approaches, on the spot, to dealing with students (Van Driel & Berry, 2012). Regarding this, Cambodian teachers did not indicate strong confidence in being an expert in the field. They may need extra support to enhance their expertise and develop mastery of their major. Continuous professional development or in-service training (INSET) program should offer for Cambodian science teachers both in subject matter and pedagogy.

In the current age of the 21st century, ICT incorporates into all aspects of life (Noor-Ul-Amin, 2013). In education, ICT gained popularity for making the teaching and learning process more and more successful and fascinating (Bhattacharjee & Deb, 2016; McFarlane & Sakellariou, 2002). It is good news that Cambodian high school science teachers showed sufficient knowledge of basic ICT regarding administration work, social communication, and knowledge and skill development. Importantly there is no gap in gender, school type and location. On the other hand, Cambodian high school science teachers did not indicate the effective use of ICT. This is critical for ICT for education (Noor-Ul-Amin, 2013). While in the information age, teachers need to be able to effectively utilize their ICT knowledge and skill in teaching in a way that can improve student learning. This seems to be challenging for Cambodian science teachers. Bingimlas (2009) addressed three major barriers effectiveness of ICT integration: lack of confidence, lack of competence, and lack of access to resources. All these barriers reflect the current situation of Cambodian high school science teachers, in which many teachers have low confidence in using ICT, do not own a computer, and lack advanced ICT knowledge. Buabeng-Andoh (2012) argued technical competency, incorporating pedagogy, is essential. It can affect effectiveness directly and mediate through confidence since competency is also a factor in improving confidence (Peralta & Costata, 2007). Technical competencies can remedy the fear of failure (Buabeng-Andoh, 2012) and the fear of damaging the computer (Peralta & Costata, 2007) and encourage teachers to use ICT in teaching. This suggests that Cambodian high school science teachers ought to master or learn more advanced ICT, including content, pedagogy and technical, especially relevant to their subject matter.

6. CONCLUSION

Cambodia high schools have acceptable infra-structure, incorporating libraries, science-laboratory rooms, computer labs, internet connection, clean water, toilet and electricity. However, science-laboratory rooms lack materials, especially for OHS. Similarly, most OHS have very few or no computers for students to learn and use to support learning.

There is a lack of classrooms, leading to having high student-to-classroom ratio and class size, especially in the capital city. The number of science teachers is also insufficient, leading to a high student-to-teacher ratio. These are the challenges for Cambodian science teachers to teach effectively.

Cambodian high school science teachers have enough knowledge of their subject content matter and pedagogical skills to teach their subjects. However, they did not indicate strong confidence in being an expert in their major. Cambodian high school science teachers showed sufficient knowledge of basic ICT regarding administration work, social communication, and knowledge and skill development, but they did not indicate the effective use of ICT. They also lack knowledge of advanced ICT, such as creating websites and coding.

As for implications, MoEYS should increase the number of high school science teacher recruitment. In Phnom Penh, MoEYS should build extra buildings in existing schools and, if possible, construct a few new high schools to share some students from existing schools which helps reduce class size and student-to-teacher ratio. For OHS, MoEYS should put more effort and investment into incrementing the number of laboratory materials, both types of items and their quantity, and the number of computers.

Cambodian teachers need extra support to enhance their expertise in their major and develop pedagogy mastery. MoEYS should have continuous professional development or INSET programs to strengthen teachers' subject content matter and pedagogy. As for ICT for education, in the short run, MoEYS should have professional development or INSET programs on how to teach effectively using ICT, and in the long run, university courses or PRESET teacher training programs should consider such a topic in the curriculum.

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Research Interest:
- Teaching technology and ICT for education
- Education assessment and evaluation
- STEM Education

Rowbraw ANN

Workplace:
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Deputy Head
Education Department

Research Interest:
- Teaching methodology
- Curriculum development
- Teaching and learning materials development
- Education policy

Samphea PEN

Workplace:
- National Institute of Education

Teacher Trainer
Education Department

Research Interest:
- Teaching methodology in Chemistry
- Development of Teaching and learning materials.
- STEM education

Samnang KHEK

Workplace:
- National Institute of Education

Vice Chief
Administration Office

Research Interest:
- Teaching Methodology in Physics
- Development of Teaching and learning materials.
- STEM education
- Education monitoring and evaluation