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Students and Teachers’ Perceptions of Inquiry-Based Learning Applied in Physics at Upper-secondary Level: A Case Study in A High School in Phnom Penh

A Mini-Thesis

In Partial Fulfilment of the Requirement for Master’s Degree of Education in Mentoring

Mel Sereynivorth

December 2021

វិទ្យាស្ថានជាតិអប់រំ

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Students and Teachers' Perceptions of Inquiry-Based Learning Applied in Physics at Upper-secondary Level: A Case Study in A High School in Phnom Penh

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December 2021

មូលន័យសង្ខេប

ដោយមើលឃើញពីប្រសិទ្ធភាព និងបញ្ហាប្រឈមផ្សេងៗ នៃការប្រើប្រាស់វិធីសាស្ត្របង្រៀនតាមបែបរិះរក តាមរយៈការសិក្សាស្រាវជ្រាវកន្លងមក ទើបជម្រុញឱ្យមានការសិក្សាស្រាវជ្រាវមួយនេះកើតមានឡើងក្នុងគោលបំណងផ្តល់ជូននូវចរិកលក្ខណៈនៃការរៀនតាមបែបរិះរក ដែលបម្រើឱ្យការអប់រំវិទ្យាសាស្ត្រជាមួយនឹងការផ្សារភ្ជាប់តួនាទីក្នុងការរិះរករវាងគ្រូ និងសិស្ស។ លទ្ធផលនៃការស្រាវជ្រាវនេះបានបង្ហាញជូននូវព័ត៌មានចាំបាច់ដែលពាក់ព័ន្ធនឹងមធ្យោបាយនៃការដាក់ឱ្យដំណើរការវិធីសាស្ត្ររៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យាក្នុងបរិបទប្រទេសកម្ពុជា។ ជាពិសេសជាងនេះទៅទៀត ការសិក្សាស្រាវជ្រាវនេះក៏ចង្អុលបង្ហាញពីការយល់ឃើញពិតប្រាកដរបស់គ្រូនិងសិស្សចំពោះវិធីសាស្ត្ររៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យារួមមាន លទ្ធផលជាផ្លែផ្កាក្នុងការសិក្សារបស់សិស្ស ក៏ដូចជាឧបសគ្គផ្សេងៗដែលរាំងស្ទះដំណើរការរៀនតាមវិធីសាស្ត្រមួយនេះ។ ការសិក្សានេះ ត្រូវបានធ្វើឡើងនៅក្នុងវិទ្យាល័យមួយក្នុងទីក្រុងភ្នំពេញដែលមានអ្នកចូលរួមចំនួន ១១ នាក់ដែលក្នុងនោះ គ្រូបង្រៀនមុខវិជ្ជារូបវិទ្យា ៦នាក់ និង សិស្ស ៥ នាក់។ ការសិក្សាត្រូវបានធ្វើជាលក្ខណៈគុណវិស័យ ដែលអ្នកចូលរួមត្រូវបានសម្ភាសន៍តាមប្រព័ន្ធអនឡាញ ដោយសារស្ថានភាពជំងឺកូវីដ១៩ ដែលមិនអនុញ្ញាតឱ្យធ្វើការជួបផ្ទាល់បាន។ លទ្ធផលនៃការសិក្សាស្រាវជ្រាវបានបង្ហាញថា លោកគ្រូអ្នកគ្រូដែលបង្រៀនមុខវិជ្ជារូបវិទ្យាបានឱ្យតម្លៃទៅលើវិធីសាស្ត្របង្រៀន និងរៀនតាមបែបរិះរក ដែលជាវិធីសាស្ត្រធ្វើឱ្យសិស្សកសាងចំណេះដឹងដោយខ្លួនឯង ជាជាងការអង្គុយរង់ចាំទទួលចម្លើយពីគ្រូ ទោះបីជាមានឧបសគ្គមួយចំនួនក្នុងការអនុវត្តវិធីសាស្ត្រមួយនេះនៅក្នុងថ្នាក់រៀនក៏ដោយ។ រីឯសិស្សវិញក៏ពេញចិត្តនឹងការរៀនតាមវិធីសាស្ត្របែបរិះរកផងដែរ ព្រោះវាបានធ្វើឱ្យពួកគេយល់ពីបាតុភូតវិទ្យាសាស្ត្រ មានបំណិនវិទ្យាសាស្ត្រ ក៏ដូចជាបំណិនទន់មួយចំនួនទៀតដូចជា ការធ្វើការងារជាក្រុម ភាពជាអ្នកដឹកនាំ ការសម្របសម្រួលក្នុងក្រុមជាដើម។ ជាការពិត ទោះបីកម្រងសំណួរសម្រាប់សម្ភាសន៍ត្រូវបានត្រួតពិនិត្យជាច្រើនលើកជាច្រើនសារ លទ្ធផលទទួលបានតាមរយៈការសម្ភាសន៍ បានត្រឹមតែការពណ៌នារបស់អ្នកចូលរួម ហើយមិនបានមើលឃើញសកម្មភាពពិតរបស់ពួកគេ។ អាស្រ័យហេតុនេះ អ្នកស្រាវជ្រាវសំណូមពរឱ្យមានការស្រាវជ្រាវក្រោយៗទៀត ដោយធ្វើពិសោធន៍ ហើយអ្នកស្រាវជ្រាវជាអ្នកសង្កេតមើល ឬបង្រៀនដោយប្រើវិធីសាស្ត្របែបរិះរកដោយផ្ទាល់ ដើម្បីទទួលបានទិន្នន័យកាន់តែសុក្រឹត និងជាក់លាក់។

ពាក្យគន្លឹះ៖ *ការរៀនតាមបែបរិះរក លទ្ធផលជាវិជ្ជមាន បញ្ហាប្រឈម ការយល់ឃើញ*

ABSTRACT

By Seeing the effectiveness and challenges of using Inquiry-Based Learning (IBL) through previous research studies, the current study was conducted to seek for understandings of the characteristics of this teaching method, which supports science education and teacher-student relations. The results of this study provided significant information related to the means of IBL implementation in physics classrooms in the Cambodian context. In particular, this study showed real perceptions of teachers and students toward Inquiry-based learning applied in physics. It also demonstrated the positive outcomes of students' studies and barriers to learning through this approach. The study was conducted in a high school in Phnom Penh City with 11 participants, including six physics teachers and five students. In this study, the researcher employed a qualitative research design, and the data was collected by In-depth Interview (IDI). The results of this study showed that teachers who taught physics perceived the values of IBL method, which is a way for students to construct their knowledge rather than sitting and waiting for answers from their teachers, even though there are some barriers to implementing this approach in the classroom. Students also enjoyed learning through this approach because it contributed them understand of scientific phenomena, including scientific process skills and soft skills such as teamwork, leadership, and coordination. Although the question guides for the interview were reviewed several times, the results obtained through the interview may not be perfectly enough. Therefore, the researchers would recommend further studies focusing on experiment research, and researchers observe or teach students using IBL methods themselves so that they receive more specific data.

Keywords: *Inquiry-Based Learning, Positive outcomes, Challenges, Perceptions*

SUPERVISOR'S RESEARCH SUPERVISION STATEMENT

TO WHOM IT MAY CONCERN

Name of program: Master's Degree of Education in Mentoring

Name of candidate: MEL Sereynivorth

Title of thesis: **Students and Teachers' Perceptions of Inquiry-Based Learning Applied in Physics at Upper-secondary Level: A Case Study in A High School in Phnom Penh**

This is to certify that the research carried out for the above titled master's thesis was completed by the above-named candidate under my direct supervision. I played the following part in the preparation of this thesis: guidance in research problem development, literature review, methodology, data analysis, and discussion finding.

Supervisor (Name): ……………………………………….

Supervisor (Sign): …………………………………..…….

Date: ……………………………………………………….

CANDIDATE'S STATEMENT

TO WHOM IT MAY CONCERN

This is to certify that the thesis that I "**MEL Sereynivorth**" hereby present entitled "**Students and Teachers' Perceptions of Inquiry-Based Learning Applied in Physics at Upper-secondary Level: A Case Study in A High School in Phnom Penh**" for the degree of Master of Education major in mentoring at New Generation Pedagogical Research Center is entirely my own work and, furthermore, that it has not been used to fulfill the requirements of any other qualification in whole or in part, at this or any other university or equivalent institution.

Signed by (the candidate): ……………………………………….

Date: ………………………………………………………………..

Countersigned by the Supervisor: …………………………………

Date: ……………………………………………………………….

ACKNOWLEGDEMENTS

This study would not have been possible if it had progressed without support, assistance, cooperation, and guidance from many people. First of all, I would like to express my deep gratitude to my supervisor, Mr. SROU Lihol, who has been abundantly helpful and has offered invaluable support, remarks, comments, and guidance throughout the entire process.

Moreover, I would like to thank the New Generation Pedagogical Research Center (NGPRC), offering this mini-thesis project. It allowed me the opportunity to learn about the process of conducting good research.

Furthermore, I would like to express my appreciation to the school principal, teachers of Physics, and students who cooperated warmly and shared experiences and ideas during the process of data collection at a high school.

Finally, deepest gratitude is also due to my parents for giving birth to me and always support and encourage me throughout my life. In particular, I would like to give special thanks to my wife, **KEO Channith**, who has supported me both materially and mentally, struggled with me, and kept me harmonious within this couple of years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ESD	: Education for Sustainable Development
IBL	: Inquiry-based learning
JICA	: Japan International Cooperation Agency
KPTTC	: Kampot Provincial Teacher Training College
MoEYS	: Ministry of Education, Youth and Sport
NIE	: National Institute of Education
PPTEC	: Phnom Penh Teacher Education College
PTTC	: Provincial Teacher Training Center
RTTC	: Regional Teacher Training Center
RUPP	: Royal University of Phnom Penh
SEAMEO	: The Southeast Asian Ministers of Education Organization
QITEP	: Quality Improvement of Teachers and Education Personnel
STEM	: Science, Technology, Engineering, and Mathematics
STEPSAM	: Secondary School Teacher Training Project in Science and Mathematics
TEC	: Teacher Education College
TRTTC	: Takeo Regional Teacher Training Center
TTC	: Teacher Training College

TTD : Teacher Training Department

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Education plays an important role to contribute to development for every country. To improve the quality of education, relevant education sectors must take responsibility to ensure that the whole education system is serving with acceptable quality. In this case, teaching methodologies are included as a part of improving education and educators have to show strong commitment to using various teaching approaches in their classrooms. When teachers ignore the important value and character of tools, instruments, and teaching techniques, this ignorance can make their teaching unattractive to students (Gutiérrez & Villegas, 2015). Inquiry–based learning, known as IBL, is a teaching approach which is gaining popularity in many developed countries. According to O'Connell (2014), Several actions are underway to strengthen science education in European nations by focusing inquiry based-learning. In some countries, science education centers are offering educators the opportunity to train and develop confidence in teaching science subjects and inquiry-based science education. This approach is mainly used in Science subjects such as Physics, Chemistry, Biology, Earth Science, etc. In addition, IBL method has been seen in social science subjects, too.

As there is an increase in number of New Generation Schools in Cambodia (Donaher & Wu, 2020), inquiry-based learning method begins to rise in practice in as a part of 21st skills for education, and it is especially used for learning Physics subject. Physics teachers use IBL method to provide valuable opportunities for students to develop their cognitive competencies and understanding of both Physics content knowledge and scientific practices. This method also helps change students' attitude towards learning Physics. The students will experience effective learning which can be classified as a type of constructivism.

1.2 Statement of the problem

Even though IBL approach is very popular in many developed countries, the implementation of inquiry learning in classrooms presents a number of significant challenges in Cambodia. According to The Teacher Training Department of the Ministry of Education (2016), Common challenges in inquiry-based learning include research question formulation, facilitating group work, providing feedback, how to respond questions that teachers have not known their answers yet, how to make a good report, distinguishing between results and inference. Students with low prerequisite knowledge of content lead to a great challenge for implementing inquiry-based learning in physics subject in upper secondary level (So, 2018). Moreover, Cambodian rural schools still face many challenges, like shortage of teaching materials and aids, libraries, and experiment labs (MoEYS, 2018a; Ren & Kosal, 2016). Inquiry science requires students take roles as scientists to generate knowledge to understand how science is developed and produced (Rakow, 1986). This reason leads to a need of manipulation of a great variety of materials by students. Rakow (1986) mentioned that teachers require time to assemble and set up the materials and plan for an active program of laboratory investigations, that is, schools have to overcome this limitation by purchasing laboratory materials assembled by science textbook publishers as supplements to their series. This is a challenge in the Cambodian context and can be a barrier of implemtation of inquiry-based learning in science education, especially in Physics classrooms.

In 2017, Cambodian Teacher Education Institutions was introduced with Education for Sustainable Development (ESD) and the aim of this workshop was to build capacity of teacher education institution leaders, teacher educators in ESD as well as inspiring them to initiate and implement ESD concepts at their institutions (RUPP, 2018). The Key targets were leaders and teacher educators from RUPP, NIE, TTD, PPTEC, and KPTTC. They attended the workshop and developed their action plan to spread ESD concepts further. Inquiry based learning was included as one of main pedagogy in lesson plans as a part of Education for Sustainable Development. However, according to the report, not all teacher trainers are enthusiastic about and implement ESD in their teaching and training and follow up with ESD implementation. In fact, the concept of IBL had been incorporated in the revised TTC curriculum, and it was implemented in all PTTCs in December 2010 and adopted in all RTTCs in November 2011(JICA, 2012). JICA has conducted a survey of the improvement of the quality of science lessons of TTC trainers, and the result has shown that both pilot school teachers and TTC teachers have some technical difficulties with IBL. Similarly, pre-service teacher training programs in Cambodia have suffered from disconnection between theory and practice (Benveniste, Marshall, & Araujo, 2008; Pich, 2017; Tandon & Fukao, 2015; Williams, Kitamura, Ogisu, & Zimmermann, 2016). "The majority of Cambodia's teacher trainers fail to provide sufficient content mastery and student-centered pedagogy" (Tandon & Fukao, 2015, p. 39). These may result in teacher trainees' limited understanding of IBL concept, and they feel hesitated to implement this student-centered approach at schools.

1.3 Research purposes

This study was intended to provide understanding of the characteristics of IBL that serve the science education in the relation to teachers and students. In particular, the finding provided essential information related to the means of IBL implementation into Physics subject in the Cambodian context. Importantly, responding to the current study's topic, this research indicated teachers and students' perceptions towards IBL approach in their classrooms. In order words, the study showed the advantages and disadvantages (known as achievements and challenges) of using IBL as teaching methodology in Physics classrooms, and how teachers and students feel about this approach. Last but not least, the present study might become a significant reference for further research studies on similar topics which can help relevant stakeholders (especially teachers and students) get more familiar with teaching and learning through inquiry.

1.4 Research objectives

The five specific research objectives are as follows:

1. To check teachers' understanding regarding the levels of IBL
2. To explore how Physics teachers apply IBL in classrooms
3. To discover positive outcomes teachers and students obtain through IBL
4. To explore challenges that teachers and students faced regarding the use of IBL
5. To explore teachers and students' perceptions regarding the use of IBL approach

1.5 Research questions

In order to achieve the objectives, five specific research questions are constructed as follows:

1. At what level do Physics teachers know and use IBL in their classrooms?
2. How do physics teachers process IBL in their classrooms?
3. What are the positive outcomes teachers and students obtain during and after learning through IBL?
4. What are challenges that teachers and students meet before, during, and after using IBL in classrooms?

5. What are teachers and students' perceptions of inquiry-based learning approach?

1.6 Significance of the study

The outcome of the study greatly benefits the following:

Students

The result provides the students with importance of learning physics through inquiry. Understanding the characteristics of inquiry-based learning helps change students' mindset of Physics dissatisfaction which has no definite basis.

Teachers

The result also provides significant keys for physics teachers to teach students by using the IBL approach. The result was collected from experienced teachers, that is, they shared their experience of conducting inquiry-based learning in classrooms including achievement they had made and challenges they had faced during teaching students through IBL. Through these shared experiences, others especially novice physics teachers can learn from them so that they can improve their abilities in teaching physics and apply inquiry-based learning model correctly and effectively.

School principals

The finding also benefits school principals. They understand the foundational support that teachers need to implement the IBL method in their classes. The school principals are ready to contribute to students so that they can achieve their studies through IBL.

MoEYS

The significance of this study further helps improve science education in Cambodia. Meanwhile the Ministry of Education, Youth and Sport is trying its effort to promote constructivism of teaching methodologies through training science teachers and organizing various workshops, this study partly contributes to collection of feedback information as well as observation and monitoring how well the science teacher have used IBL method with appropriate levels with students, what that have been done successfully, and what to be improved. The result of the study is useful for MoEYS to check whether IBL, which is one of constructivism of teaching methodology, has efficiency in teaching physics as well as other science subjects.

1.7 Operational definition of key terms

Inquiry-Based Learning (known as IBL) is a teaching methodology that supports a student-centered approach followed by constructive learning theory. Regarding the IBL, students are encouraged to seek answers that respond to their research questions, rather than receive direct instruction from the teacher. It means that students are supposed to construct knowledge by themselves, and the teacher just comes to facilitate them only. The students are motivated to learn to build content knowledge based on objectives of lessons. In this approach, the teacher has to have such a lot of patience and put trust in the students achieving their learning through inquiry.

1.8 Summary of the chapter

This chapter has consisted of seven major sections: background of the study, statement of problem, research purposes, research objectives, research questions, significance of the study, and operational definition of key terms. First of all, in the background of the study, it reviewed the popularity of inquiry-based learning in science education in many countries and the start of putting IBL into practice for the Physics subject in the Cambodian context. Then, in problem statement, Cambodian rural schools still face many challenges which become barriers to the implementation of inquiry-based learning in science education, especially in Physics classrooms. Moreover, the fundamental purpose of this study was to provide an understanding of the characteristics of inquiry-based learning, provide essential information related to the means of IBL implementation into Physics subject, and indicate the exact perceptions formed by teachers and students towards the IBL approach. Furthermore, it came up with five research objectives and five research questions to be answered in this study. In addition, the significance of this study was to benefit students, teachers, and MoEYS regarding the implementation of IBL. Last but not least, one key term was written in this study: Inquiry-Based Learning (IBL). The next part, chapter 2, will show the literature review which is related to this study.

CHAPTER 2: LITERATURE REVIEW

2.1 History of Inquiry-Based Learning

Inquiry-based learning is firstly a methodology in pedagogy that was grown during the discovery learning movement of the 1960s. It responded to traditional forms of instruction where learners were required to revise information from instructional materials (Joseph Schwab, 1966) as cited in (Barrow, 2006). In fact, the philosophy of inquiry based learning existed in constructivist learning theories and was promoted by notable scholars such as John Dewey, Lev Vygotsky, Jean Piaget, and Jerome Bruner (Snowman, McCown, & Biehler, 2009).

John Dewey has found inquiry in experience and has explained the pattern of inquiry, which is originated in human culture, language and everyday experience. According to Dewey, learning experiences should be done in collaboration and placed in an aspect of reconstruction of knowledge. Dewey also mentioned the role of reflection. While describing practical forms of inquiry, he added three situations: pre-reflection, reflection and post-reflection (Constantinou, Tsivitanidou, & Rybska, 2018).

In the 1960s Joseph Schwab demanded inquiry to be divided into three distinct levels (schwab, 1960). This was later formalized by Marshall Herron in 1971, who was the founder of the Herron Scale to evaluate a particular lab exercise through the amount of inquiry. It was a four-point scale that ranked from level zero to level three, describing in terms of students' degree of "openness." (Herron, 1971).

Table 1 Schwab/Herron Levels of Laboratory Openness (adapted from (Azinoor, Farina, Zuhaida, Fauzi, & Muhamad, 2018))

Level	Problem	Ways & Means	Answers
0	Given	Given	Given
1	Given	Given	Open
2	Given	Open	Open
3	Open	Open	Open

From then on, there have been a number of revisions proposed, and inquiry can be seen in various forms. For example, “inquiry and design framework,” which people understand by Design, “disciplinary-specific inquiries” like Cognitively Guided Instruction in Math and Physics, and involves project-based learning and problem-oriented or case-based learning. There is a range of opinions of inquiry-based teaching approach available (J. D. Wilhelm & Wilhelm, 2010).

2.2 Definition of IBL

Inquiry is the planned process of recognizing situations, constructing problems, analyzing experiments and differentiating alternatives, organizing investigations, researching hypotheses, searching for information, constructing simulations, discussion with peer using evidence and representations and creating coherent reasons (Linn, Davis, & Bell, 2004 as cited in Constantinou et al., 2018). Student inquiry refers to an activity that enables students to conduct observations, come up with questions, examine instructional materials and other sources of information so that they can see what is already known. The students investigate, review what is already known in light of their experimental evidence. They also use tools to collect, analyze, and interpret data, propose answers, explain, make predictions, and discus the results (Hussain, Azeem, & Shakoor, 2011).

Regarding the term IBL, which is Inquiry Based Learning, "is a learner-centered pedagogy in which students play an active part in the process of knowledge discovery or acquisition" (Fernandez, 2017, p. 2). Inquiry-based learning is a strategy in education which students work as the roles of professional scientists in order to construct knowledge (Keselman, 2003). It can be characterized as a process of discovering new causal relationships among variables, and the learner formulate hypotheses and test them by conducting experiments with observations or making observations without experimental process (Margus Pedaste, Mäeots, Leijen, & SaraPuu, 2012). Inquiry-based learning focuses on and learner's active participation and responsibility for discovering new knowledge (Jong & Joolingen, 1998).

2.3 Characteristics of IBL

2.3.1 The levels of IBL

There are many different explanations for inquiry teaching and learning and the various levels of inquiry depending on contexts. The articles titled "*Assessing Inquiry Potential: A Tool For Curriculum Decision Makers*" and "*The Many Level of Inquiry*" clearly outline four levels of inquiry (Banchi & Bell, 2008; Tafoya, Sunal, & Knecht, 1980).

Level 1: Confirmation inquiry

The teacher has introduced a particular scientific principle or concept to the students. The teacher then forms questions and a procedure that lead the students through a predicted activity where the results are already supposed to happen. This method is very useful to improve concepts taught and to introduce students into a way of learning that come after procedures, collect and record data and to confirm and students' understandings.

Level 2: Structured inquiry

The students are provided with the initial question and an outline of the procedure. The students then asked to formulate explanations of their findings based on evaluating and analyzing the data that they collect.

Level 3: Guided inquiry

In this level, the students are only provided with the research question from the teacher. The students are responsible for developing and directing their own procedures to test the question and then present and explain their results and findings.

Level 4: Open/True inquiry

Students formulate their own research problem(s), create a developed procedure to solve the problem(s), and communicate their findings and results. This level of inquiry is common used in science studies where students push their own investigative questions.

Table 2 Levels of inquiry on teacher agency and learner autonomy (Tafoya, Sunal, et al., 1980)

	Level 1 Confirmation Inquiry	**Level 2 Structured Inquiry**	**Level 3 Guided Inquiry**	**Level 4 Open/True Inquiry**
Problem	Teacher-led	Teacher-led	Teacher-led	Student-initiated
Procedure	Teacher-led	Teacher-led	Student-initiated	Student-initiated
Solution	Teacher-led	Student-initiated	Student-initiated	Student-initiated

Similarly, Fay and Bretz (2008) described levels of the IBL rubric for comparing laboratory activities. The rubric is based on the theory that students' freedom is at distinguishable degrees. Slightly different from Banchi and Bell (2008), the four levels of inquiry-based learning progress from 0 to 3, increasing responsibility to students with decreasing direction from teachers (see table 3).

Table 3 Levels of inquiry rubric (adapted from(Fay & Bretz, 2008))

Level	Problem/Question	Procedure/Method	Solution
0	Provided to students	Provided to students	Provided to students
1	Provided to students	Provided to students	Constructed by students
2	Provided to students	Constructed by students	Constructed by students
3	Constructed by students	Constructed by students	Constructed by students

According to Banchi and Bell (2008), teachers should start their inquiry instruction at the lower levels and continue their ways to open inquiry so that they gradually develop students' inquiry skills in effective ways. Open inquiry activities are done successfully if students are motivated by intrinsic values and if they are well-prepared with the skills to conduct their own research study (Yoon, Joung, & Kim, 2012).

2.3.2 IBL procedure

Inquiry based learning can contribute to developing questions, making observations, doing research to find out what information is already recorded, developing methods for experiments, developing instruments for data collection, collecting, analyzing, and interpreting data, outlining possible explanations and creating predictions for future study (Mäeots, Pedaste, & Sarapuu, 2008).

Specific learning processes that learners engage in during inquiry-based learning (Friedler, Nachmias, & Linn, 1990; M. Pedaste & Sarapuu, 2006; Veermans, 2002) include:

- problem identification

- research question formulation
- hypothesis formulation
- experiment planning
- carrying out an experiment
- analysis and interpretation of results
- drawing conclusions and presenting the findings

2.4 IBL in science education

A number of support in Inquiry-based learning in science education is increasing with a number of educators who are interested in teaching which involves inquiry (Polman, 1998). John Dewey, which was a well-known educational philosopher at the beginning of the 20th century, was the first person who argued the fact that young scientific thinkers should have been developed in science education in a way that was not taught directly. He suggested that science should be taught in a form of a process and way of thinking rather than memorizing what students learned (Council, 2000). While Dewey was the first person to point up this issue, Joseph Schwab spent lifelong work and efforts on the reform within science education. Joseph Schwab, an educator, suggested that science could be a driven process of thinking and learning with flexibility and multi-directional inquiry. Schwab mentioned that science in the classroom should be active like scientists conducting research (G.E, 2014). In addition, science process skills are advantageous to students to inseparably practice, starting from the conceptual understanding in learning to apply science in inquiry in the science laboratory. Science process skills have two degrees: Science process skills (observing, classifying, measuring, and predicting) and Integrated Science Process Skills (defining variables, transforming data, constructing tables of data, interpreting data, formulating hypotheses, drawing conclusions, and generalizing, etc.) (Karamustafaoğlu, 2011).

The National Science Education Standards (Council, 1996) details both the abilities necessary to do scientific inquiry and the understandings about scientific inquiry. The abilities and understandings about inquiry that students in grades 9–12 should meet are included in tables 4 and 5. The abilities and understandings about inquiry are matched to the 4 levels of IBL in table 6 (Grady, 2010).

Table 4 Abilities necessary to do scientific inquiry (Council, 1996)

Abilities necessary to do scientific inquiry
1. Identify questions and concepts that guide scientific investigations.
2. Design and conduct scientific investigations.
3. Use technology and mathematics to improve investigations and communications.
4. Formulate and revise scientific explanations and models using logic and evidence.
5. Recognize and analyze alternative explanations and models.
6. Communicate and defend a scientific argument

Table 5 Understandings about scientific inquiry (Council, 1996)

Understandings about scientific inquiry
7. Scientists inquire about how physical, living, or designed systems function. Conceptual and scientific knowledge influence the design and interpretation of investigations and the evaluation made by other scientists.
8. Scientists conduct investigations to discover aspects of the natural world, explain observed phenomena, or test conclusions of prior investigations or the predictions of theories.
9. Scientists rely on technology to help gather and manipulate data.
10. Mathematical tools and models guide and improve the posing of questions, gathering of data, constructing of explanations and communicating results.
11. Scientific explanations must be logically consistent, abide by the rules of evidence, be open to questions and possible modification; and be based on historical and current scientific knowledge.
12. Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists.

Table 6 The inquiry matrix (Grady, 2010)

	Level of Scientific Reasoning Tasks Least complex → Most complex			
Six Abilities for Inquiry	**Pre-inquiry**	**Developing Inquiry**	**Proficient Inquiry**	**Exemplary Inquiry**
1. PROBLEM: Identify questions and concepts that guide scientific investigations				
Generating scientifically oriented questions	Students do not contribute to the investigation question; it is provided by the teacher or curriculum.	Students make small revisions to the investigation question based on questions provided by the teacher or curriculum.	Students choose from a pool of questions; the teacher provides guidance, boundaries, and support for the investigation question.	Students generate the question for investigation based on their own experiences, knowledge, and research. The teacher plays little to no role.

Making predictions or posing preliminary hypotheses prior to conducting investigations	Students do not pose preliminary hypotheses or make predictions; these are provided by the teacher or curriculum materials.	Students choose from possible predictions or preliminary hypotheses provided by the teacher or curriculum materials.	Students generate their own relevant and testable predictions or preliminary hypotheses, without conducting prior investigations of the research question or a literature review.	Students generate their own relevant, testable, and falsifiable preliminary hypotheses based on prior investigations of the research question or a literature review.
2. PROCEDURE: Designing and conducting the research investigation				
Designing the procedure for the investigation	Students do not contribute to the design of the investigation; these are provided by the teacher or curriculum.	Students make limited contributions to the procedure.	Students make numerous contributions to the procedure.	Students design most of the procedure with limited support from the teacher.
Selecting dependent and independent variables	Students do not choose variables; these are provided by the teacher or curriculum.	Students choose variables but have no rationale for their choices.	Students choose variables and have limited rationale for their choices.	Students have a thoughtful, scientific rationale for their choices of variables.
Considering experimental controls and conditions that need to be controlled	Students give no attention to the design of controls, and conditions that need to be controlled, these are provided by the teacher or curriculum.	Students give minimal attention to the design of controls and conditions that need to be controlled.	Students give some attention to the design of controls and conditions that need to be controlled.	Students give purposeful, focused attention to the design of controls and conditions that need to be controlled.
Gathering and organizing data during the investigation	Students do not collect data; the data is provided by the teacher or curriculum materials.	Students gather and record data, giving little to no thought to the representations (e.g., tables, drawings, or photos) of the data.	Students gather and record data, giving some thought to the representations of the data with some contributions from the teacher.	Students gather and record their own data, giving consideration to the representations of the data, with little to no contribution from the teacher.
3. PROCEDURE: Use technology and mathematics to improve investigations and communications				
Analyzing data using calculations, graphing, and statistical analyses; looking for anomalous data	Students do not analyze data; the data analysis is provided by the teacher or curriculum materials.	Students conduct some of the data analysis; much of the analysis is done by the teacher.	Students conduct their own data analyses with some contributions from the teacher.	Students conduct their own data analyses with little to no contribution from the teacher.
4. SOLUTION: Formulate and revise scientific explanations and models using logic and evidence				

Identifying the evidence from the analyzed data	Students do not identify evidence from the data; the teacher or curriculum materials identify the evidence.	Students identify the evidence from the data; much of the analysis is done by the teacher.	Students identify the evidence from the data; some contributions to the analysis are done by the teacher.	Students identify the evidence from the data with little to no contribution from the teacher.
Providing explanations	Students do not provide explanations; the teacher or curriculum materials provide the explanations.	Students provide explanations with significant contributions from the teacher.	Students provide explanations with significant contributions from the teacher.	Students provide explanations with little to no contribution from the teacher.
5. SOLUTION: Recognize and analyze alternative explanations and models				
Note unexpected findings, addressing accuracy of data, experimental errors, limitations, or flaws	Students do not note unexpected finding, addressing accuracy of data, experimental errors, limitations, or flaws; the teacher provides these.	Students note with significant contributions from the teacher the unexpected findings, addressing accuracy of data, experimental errors, limitations, or flaws.	Students provide explanations with some contributions from the teacher the unexpected findings and addressing accuracy of data.	Students note with little to no contribution from the teacher the unexpected findings, addressing accuracy of data, experimental errors, limitations, or flaws.
Connecting evidence with scientific knowledge	Students do not connect the evidence to scientific knowledge; the teacher or curriculum materials provide the connections.	Students make the connections between the evidence and scientific knowledge with significant contributions from the teacher.	Students make the connections between the evidence and scientific knowledge with some contributions from the teacher.	Students make the connections between the evidence and scientific knowledge with little to no contribution from the teacher.
Posing and analyzing alternative explanations and predictions	Students do not address alternative explanations for evidence or predictions; the teacher or curriculum materials provide alternative explanations and predictions.	Students pose alternative explanations and predictions with significant contributions from the teacher.	Students pose alternative explanations and predictions with some contributions from the teacher.	Students pose and analyze alternative explanations and predictions with little to no contribution from the teacher.
6. SOLUTION: Communicate and defend a scientific argument				
Communicating and defending findings through discussion, presentations, or written reports	Students do not communicate and defend their findings; the teacher communicates the findings to the students.	Students communicate and defend their findings with significant contributions from the teacher.	Students communicate and defend their findings with some contributions from the teacher.	Students communicate their findings with little to no contribution from the teacher. Students use logical arguments to defend their findings.

Nowadays, students at all levels of education can successfully experience and develop their level thinking skills more deeply through scientific inquiry (Council, 1996). In Hampshire College, McMaster University in Canada, students are taught through inquiry-based learning so that they will become self-directed learners and take more responsibility for how to construct knowledge in their own ways (McMaster University, 2007 as cited in (Spronken-Smith, 2012)). The graduated levels of scientific inquiry indicated by Schwab demonstrate that students are required to have thinking skills and strategies prior before they are exposed to higher levels of inquiry (G.E, 2014).

3.1 IBL in Physics subject

Inquiry-based learning helps students learn by participating in activities that reinforce physics concepts. Inquiry-based learning works by showing students with authentic questions, observations, rather than showing concepts taught by teachers. This process promotes the active engagement of students, and has been presented as results in the increased learning and retention of ideas (Mathematics, 2016).

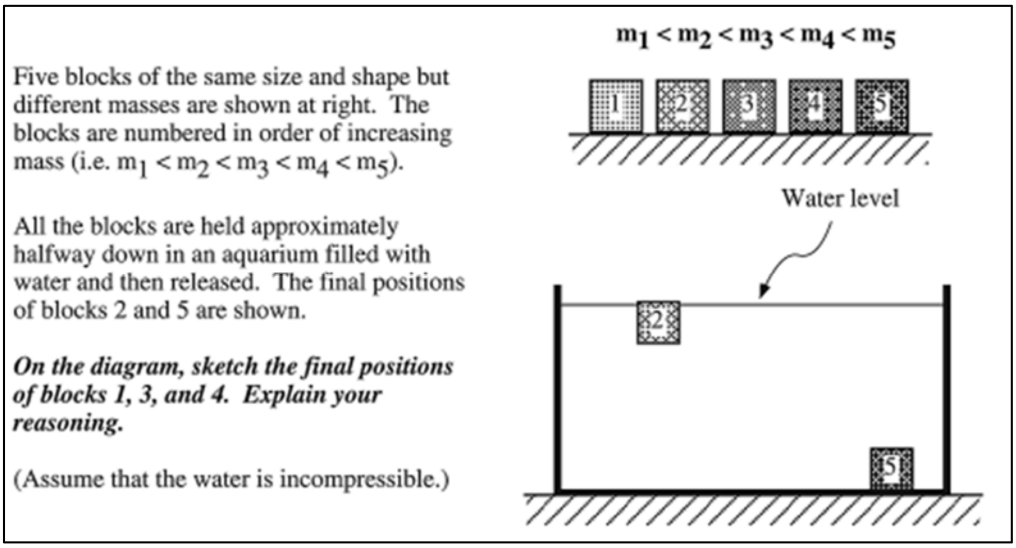

Figure 1 The five block problem (Loverude, Gonzalez, & Nanes, 2011)

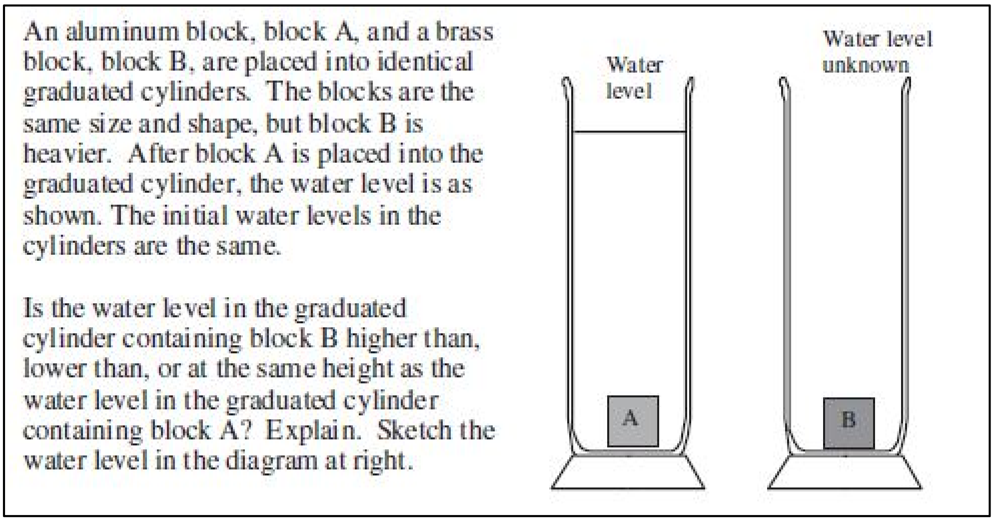

Figure 2 The water displacement problem (Loverude et al., 2011)

Majority of teachers fail to employ inquiry teaching methods in their classrooms, and this become a question posed by philosophers and psychologists. According to ostenson and Lawson (1986), there are ten reasons that are the challenges of using inquiry in classroom. A significant reason involves with teaching habits which impact teachers' change of traditional teaching styles to inquiry method. If "Teachers tend to teach as they were taught. If they were taught through lecture, they are likely to lecture, even if such instruction is inappropriate for their students" (McDermott, Shaffer, & Constantinou, 2000, p. 72).

McDermott et al. (2000) indicated that the teachers find it difficult to develop good inquiry-oriented instructional materials. However, on the basis of direct experience with the intellectual demands of learning by inquiry, teachers are well- prepared to meet the challenge of matching their instruction with their students' level of developmental.

3.2 Common views of IBL

3.2.1 Benefits of IBL

There are many reasons that foster teachers to increase the use of IBL in their classrooms, and all of them are related to the benefits that students will obtain from this approach. According to different authors, benefits have been identified as the following:

- IBL increases students' achievement significantly in mathematics and science, regardless their lower levels of self-confidence and unfavorable backgrounds (Rocard et al., 2007).
- Students will understand and remember content knowledge of science better (Walker, 2015).
- IBL helps increase students' ability through learning with understanding, and this ability contributes to the use of their knowledge in new situations and contexts (transferability of knowledge) (Dorier & Maaß, 2012).
- IBL helps promote critical thinking skills and the development of key competencies (Hattie, 2009).
- In the IBL process, students are mainly self-directed learners with partly inductive and deductive learning processes. They do experiments to investigate the relations between dependent and independent variables (P. Wilhelm & Beishuizen, 2003).
- IBL give students with opportunities to develop a wide range of complementary skills such as group work, writing in verbal expression, experience of open-ended problem-solving and other cross-disciplinary abilities (Rocard et al., 2007).
- Students will understand of how scientists generate knowledge and how the current scientific knowledge was developed and produced (Rakow, 1986;

Walker, 2015). As a result, students will create a more balanced and realistic perception about science, its nature, and the way it is created and developed.

- IBL has positive effect on students' attitudes and motivation towards science studies. They find math and science subjects more interesting and exciting (Dorier & Maaß, 2012).
- IBL may affect students' willingness to continue studying scientific disciplines and getting involved in scientific careers (Dorier & Maaß, 2012).
- IBL approach may be an effective way to grow girls' interest, self-confidence and participation in scientific activities (Rocard et al., 2007).

3.2.2 Challenges of IBL implementation

Even though IBL has great benefit on constructive development, obstacles and problems hinder the increase of a wide uptake of IBL. Anderson and D. (1996) stated three problems that are the barriers of the use of constructive approaches in teaching. These include:

- **Technical problems**, like limited teaching ability of teachers, challenges of assessment, struggling with group work management, misunderstanding of teachers and students' roles, inadequate in-service education.
- **Political problems**, like limited in-service education, parental resistance, resistance between principals and other educational authorities, differing judgments between justice and fairness.
- **Cultural problems**, like teachers' belief, views of assessments, preparation ethics.

Although theses problem could contribute to the limited impact of IBL in classrooms, teachers are supposed to play important role that can make IBL happen in classroom.

Noticing obstacles and barriers they see for the use of IBL is very important in professional development programs (Dorier & Maaß, 2012).

Walker (2015) and Rakow (1986) worked differently to collect problems that teachers normally face when applying IBL in the classrooms as the following:

- Inquiry-based science takes more time
- Teacher loses control
- Problems with safety
- Inquiry based lessons might not "work"
- Lack of resources
- Inquiry is only of value to high ability students
- Student resistance to inquiry
- Lack of training and support
- Difficulty of assessment

In the context of the emphasis on inquiry teaching in science education, pre-service elementary teachers' understanding and practicing science inquiry teaching during field experience have been taken into account (Yoon et al., 2012). While the practice of hypothesis-based inquiry teaching was a very useful approach for teachers, it is not easy for them put the process of hypothesis-making, test design, and justification into practice with students in the classrooms. Yoon et al. (2012) found six difficulties of inquiry teaching and categorized them in two dimensions: 'on the lesson' and 'under the lesson'.

Findings I: Difficulties 'on the lesson'

- Difficulty 1: Developing Children's Own Ideas and Curiosity

- Difficulty 2: Guiding Children in Designing Valid Experiments for their Hypotheses
- Difficulty 3: Scaffolding Children's Data Interpretation and Discussion

Findings II: Difficulties 'under the lesson'

- Difficulty 4: Tension Between Guided and Open Inquiry
- Difficulty 5: Incomplete Understandings of Hypotheses
- Difficulty 6: Lack of Confidence in Science Content Knowledge

Lawson (2000) mentioned the common issues novice teachers encounter in managing IBL classroom. Some of them are listed below:

- Some students do not participate enough
- Some student do not know how to get the inquiry started
- Some students do not care and do not see the inquiry as relevant to their lives
- Some students lack of background knowledge for inquiries
- Some students have bad attitude and are disruptive
- Some students do not want to think for themselves
- Some students do not listen, are bored and disruptive

The training of teachers in the inquiry approach is a significant challenge in science education in many countries. This will become new questions how to establish effective strategies to continue strengthening the inquiry approach among teachers, and make it in progress implementation inquiry activities with greater levels of openness in different topics of the curricula and designation of coherent evaluations of this teaching model (Pérez & Furman, 2016).

Inquiry training model have positively significant impact on traditional teaching methods on students' academic achievement. Therefore, teachers should consider how to prepare learning environments in which students will be active in accordance with their characteristics and then introduce these environments to students (Abdi, 2014).

3.2.3 Teachers and students' perceptions of IBL

Teachers think that inquiry is an effective learning approach that contributes to students' learning and active motivation. Inquiry instruction benefits all students with varying backgrounds, helping them to be engaged in the process of learning. However, the inquiry takes time and a lot of preparation to ensure its achievement (Eltanahy & Forawi, 2019).

Students expressed positive perceptions and attitudes toward inquiry learning strategy. IBL process changes their feeling about studying science and makes them excited to engage in science classes as mentioned by (Rubani, Ariffin, Subramaniam, & Hamzah, 2017), although they have some difficulties with time constraints (Eltanahy & Forawi, 2019). Moreover, according to (Baldock & Murphrey, 2020), students also raise beneficial aspects of inquiry-based learning that give them opportunities to learn by themselves, gain knowledge, be different, have an experience, use prior knowledge, and entertain.

3.3 IBL in the Cambodian context

3.3.1 Various actions relevant to IBL

Training science teachers

STEPSAM, which is **Secondary School Teacher Training Project in Science and Mathematics,** found that Fundamental issues in the science and mathematics education have occurred. These include learning without the understanding of the concepts of science and mathematics. Moreover, teaching focuses on memorization of science and mathematics, and they do not pay attention to theoretical structures, common misconceptions and so on (Agency, 2016). In order to deal with these situations, "STEPSAM2 introduced inquiry-based learning into Provincial Teacher training Centers (PTTC) and Regional Teacher Training Centers (RTTC), and STEPSAM3 introduced the Teacher's Guide to change the daily lessons of the teachers. NIE trainers gave instructions to the trainers of PTTC and RTTC in STEPSAM2, and RTTC trainers became INSET trainers for lower secondary teachers in STEPSAM3 (Agency, 2016, p. 71)."

SEAMEO QITEP in Science (SEAQIS) arranged a workshop called In-Country Training on Inquiry Based Science Education in Preparing for STEM Education in Phnom Penh, Cambodia, starting from 4 to 6 December 2017. In cooperation with the Ministry of Education, Youth and Sports of Cambodia, the program was attended by 35 people, including of Junior High School science teachers, science teacher trainers and Cambodia government officials related to science teacher coaching. At the end of the training, the participants felt enthusiastically to improve their pedagogy competence and the quality of science learning in the classroom in expectation to achieve the ultimate goal: enhancing students' literation in science(Agustiani, 2017).

In cooperation with the Teacher Training Department, an organization known as *The Cambodia Charitable Trust* has created a platform to bring Trainers and in-service teachers together so that they develop a training and practicum system with the best of theory and practice through Inquiry-based Learning and Lesson Study. This is transforming teacher education in Cambodia (Trust, 2017).

According to Teacher Policy Action Plan, in strategy 4: Developing teacher training institutions, The Ministry planned to develop the infrastructure of the teacher training centers. These included upgrading TTC infrastructures, teaching and learning materials, ICT facilities, laboratories, toilets, dormitories and constructing additional science laboratories in 14 TTCs (MoEYS, 2015).

MoEYS has established strategic action plan for Teacher Training Reform at Teacher Education Institutions (Ministry of Education, 2019), such as reviewing teacher training programmes at National Institute of Education (NIE), Teacher Education Colleges (TECs) and RTTCs, ensuring training equivalence, especially in STEM, ICT and foreign languages as well as strengthening the capacity of trainers on subject-based knowledge, teaching methods and ICT.

Putting IBL into practice

The Ministry emphasizes the importance of critical thinking that make students in preparation for future employment because employers need employees with analytical thinking and decision-making as skilled and semi-skilled work (Bredenberg, 2018). To achieve the goal, students should be receiving education through teaching methodologies that help develop other cognitive competencies like critical thinking and problem-solving abilities. If we have a look at New Generation Schools (NGS) reform, which this program provides autonomy with the aim of encouraging curriculum innovation including instructional practices to ultimately improve students' learning outcomes and prepare them for the workforce in the twenty-first century, the Schools have been generating problem-based learning and constructivist teaching methods. Problem-based learning is an inquiry-based learning where students learn through discussion of open-ended and real-world problems. Similarly, constructive learning is an active process that students contextualize information and construct meaning based on their experiences of life. The students are required to utilize critical thinking skills to analyze relevant real-world problems through both approaches (Donaher & Wu, 2020).

A finding of students' competency through inquiry at university

Even though Cambodian university students with little previous exposure of inquiry based learning from their high school studies, they are highly receptive and adapt quickly to inquiry strategies. Dickinson, Ford, Galloway, and Lemke suggested that longitudinal effects of inquiry on student success and teaching practices is in need of examination. Cambodian pre-service teachers are required to shapes their future practice of teaching through inquiry whether they experience in this constructive approach (Dickinson, Ford, Galloway, & Lemke, 2011).

3.3.2 Common issues and challenges to IBL

While IBL is an effective teaching approach that helps contribute to the development of students' critical thinking skills, several challenges have been found as limitations of uptake of IBL. Those challenges are categorized into three main factors that are the barriers to IBL implementation as the following:

Infrastructure

Most Cambodian Schools stills have limitations of major teaching aids such as textbooks, libraries, electricity, laboratories, teaching materials, and teacher's guide, reference books for teachers, tables, as well as school buildings (MoEYS, 2018a; Ren & Kosal, 2016). In Physics course, students are supposed to have more activities in experiments and this requires appropriate facilities like materials, laboratories, and other teaching aids. Moreover, it is necessary for having those teaching and learning supports if students learn through IBL approach. In the Cambodia context, this is an issue for teachers who wish to implement IBL in the classrooms.

Teachers

Teachers play a very important role in providing students the education with critical thinking ability through inquiry. However, they still struggle with this approach due to some reasons. Even though the concept of IBL have been introduced into Cambodian teacher training institutions in 2010, pilot school teachers as well as TTC teachers are still facing some challenges with techniques (JICA, 2012). Three major difficulties are found as below.

1) Difficult to apply IBL in lessons without experiment
2) Difficult to develop key questions
3) Difficult to manage time for preparation and during lessons.

In 2017, Cambodian Teacher Education Institutions was introduced with Education for Sustainable Development, and the purpose of this workshop was to build capacity of teacher education institution leaders, teacher educators in ESD as well as inspiring them to initiate and implement ESD concepts at their institutions (RUPP, 2018). Leaders and teacher educators from Royal University of Phnom Penh (RUPP), National Institute of Education (NIE), Teacher Training Department (TTD), Phnom Penh Teacher Education College (PPTEC), and Kampot Provincial Teacher Training College (KPTTC) were the target for attending this program so that they learned developing their action plans to further spread ESD concepts with their trainees. Inquiry based learning was included as one of main pedagogy in lesson plans as a part of Education for Sustainable Development. However, according to the report, not all teacher trainers are enthusiastic about and implement ESD in their teaching and training and follow up with ESD implementation.

In addition, many researchers have found that Cambodian pre-service teacher training programs have found difficult to make connection between theory and practice due to a current shortage of qualified teacher trainers (Benveniste et al., 2008; Pich, 2017; Tandon & Fukao, 2015; Williams et al., 2016). According to Tandon and Fukao (2015), many teacher trainers are unable to teach meaningful content mastery and they still use teacher-centered teaching approach instead of student-centered pedagogy. This action might influence their trainees to continue teaching styles, that is, IBL, which is one of student-oriented approach, is rarely implemented in schools.

Students

As being mentioned earlier, the concept of IBL requires students to seek answers that respond to their research questions, rather than receive direct instruction from the teacher. Students must have prerequisite knowledge to conduct their inquiry. Recently, there was a study about promoting student understanding on Projectile Motion by using Inquiry-Based Learning approach (So, 2018). The study was conducted in a high school in Tbong Khmum Province with more than 100 eleventh graders. So (2018) pointed out that students' background knowledge and inadequate teaching infrastructure were the main challenges of inquiry based learning implementation in physics subject for the study. Moreover, Cambodian students' tendency towards social science classes rises significantly in the last six years. According to Soprach (2019), "the increase in the number of students taking the social sciences class has seen an 18-fold increase, from 2,492 in 2014 to 45,002 in 2018 (Ministry of Education), while those studying the science class has remained at around 30,000." This is partly shown that Cambodian students do not like studying science subjects. Students' participations are really significant to generate true inquiry based learning in the classrooms.

3.4 Expectations of further IBL implementation

The Ministry of Education, Youth and Sport has established the Cambodia Education 2030 Roadmap, which will focus on providing quality services, equity, technical and vocational education, especially life-long learning to improve quality effectiveness, job productivity, in line with technological age of promoting economic and social prosperity (The Ministry of Education, 2019). Cambodian Teachers and students are the cores vision of human capital.

Cambodia's vision of a teacher for 2030

Cambodian teachers will be professionally competent, motivated, supported, and equipped with sufficient academic contents. They will have pedagogical skills and a passion for teaching and love for their students. Moreover, teachers will be continuously supported to develop their content knowledge and competencies that best promote student learning.

Cambodia's vision of a student for 2030

Cambodian students will be well-prepared and motivated to learn regardless of their background. They will receive education through professionally competent and qualified teachers, that is, they will be equipped with both hard and soft skills enabling them to contribute to and actively participate in the society.

To reach this goal, the Ministry of Education has made noticeable reforms to improve the quality of education such as teacher training institutions, developing teachers' capacity and teacher education centers, especially strengthening the capacity of trainers on subject-based knowledge and teaching methods (Ministry of Education, 2019). Along with these reforms, inquiry based learning is expected to further be implemented on teacher training institutions, new generation schools as well as normal schools throughout Cambodia.

3.5 Summary of this chapter

This chapter has reviewed in six major sections: the history of IBL, IBL definition, characteristics of IBL, IBL in science education, common views of IBL, and IBL in the Cambodian context. The first section started with the history of IBL rising in the 1960s as a part of constructive learning. Later on, IBL was developed in various forms by next-generation scholars. IBL focuses on students' activities to find new knowledge by themselves, and those activities define the four levels of IBL. IBL is often used in science education, including Physics courses. Students who study through IBL gain their improvement and development of constructing knowledge, soft skills, and attitude. However, the applications of IBL in classrooms face some problems.

In Cambodia, IBL is taken into account of establishment in teacher training institutes so that teachers are aware of it before applying it to students. However, there are limitations of IBL applications due to various issues like shortage of teaching materials, low commitments, inadequate training, etc. In this case, the Ministry of Education, Youth and Sport has not ignored those concerns and is currently trying to make a new reform of education to make IBL active again and to respond to further vision in the future. The next chapter, chapter 3, will present the method to collect data in this study.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter shows research design, sample size and sampling technique, research instruments, data collection procedure, and data analysis. It includes a description of scope of the study, some limitations of various methods and a discussion of ethical issues that may occur in conducting the study.

3.1 Research design

Qualitative case study was employed in this study in order to reach the aims and objectives of the study. Qualitative case study is a research methodology that contribute to exploration of a phenomenon within a particular context through various data sources, and it conducts the exploration through variety of observation in order to reveal multiple parts of the phenomenon (Baxter & Jack, 2008). In case study, researchers explore a real-time phenomenon within its naturally occurring context, with the consideration that a difference will be created by the context (Kaarbo & Beasley, 1999). Because the current study was conducted to explore students and teachers' perception of inquiry-based learning in Physics, the researcher collected data from Physics teachers and students in a high school in Phnom Penh City. Therefore, qualitative case study using semi-structured interview was suitable for the nature of the current study.

3.2 Sample size and sampling technique

The researcher selected 6 physics teachers who teach students at upper-secondary level and 5 upper-secondary students (3 in grade 10, and 2 in grade 11) by using the snowball sampling technique in a high school in Phnom Penh City.

Since the current research is a case study, the researcher chose teachers and students who have experienced with inquiry based learning applied in physics course with an above-mentioned number. Due to a small number of the physics teachers, the researcher asked all of them to participate in the study. In contrast, the targeted number of the students was selected for participation in this research because the researcher could not interview all upper secondary level students at the school. The researcher used the snowball sampling technique to choose student participants. It meant that the teacher participants were asked to assist the researcher in identifying outstanding students and those who were low-performing. The researcher selected three outstanding students (twos students were in grade 10 and another was in grade 11) and two students with poor performance (one in grade 10 and another in grade 11). The researcher did not interview average-performing students because the findings received from outstanding and low-performing students could sufficiently help the researcher synthesize the data and estimate it in an average of students' learning through IBL.

The researcher had planned to interview four students from each teacher. However, only two teachers allowed the researcher to meet their students. Moreover, some students' parents did not allow their children to participate in the study even though the researcher had sent a consent letter with explanation. This problem made the number of students who participated become less.

3.3 Research instrument

As this study employs a qualitative research design, the semi-structured interview was employed with all respondents. The researcher had planned to use an observation instrument to triangulate the information. According to Creswell, Fetters, and Ivankova (2004), qualitative data consisted of both semi-structured interviews and field observations which are analyzed by coding to develop themes and categories(Staples, 2008). However, due to Covid-19, the school closed, and the researcher could use the semi-structured interview through online only.

The interview was established by using the semi-structured interview questions, which were consulted with the researcher's supervisor with a set of questions to be asked the participants during the interview process. This semi-structured interview questions were divided into five sections with specific set of close-ended and open-ended questions (see appendixes A-B).

3.4 Data collection procedure

This section describes the procedures that the researcher used to collect data. In this section, the researcher used the above instrument to collect data. First, the researcher met the school principal at the selected high school in Phnom Penh. He explained the purpose of the study and submitted a consent letter to him. After getting approval from the school principal, the researcher was allowed to meet the targeted teachers, and he sent them the consent letter and asked them permission to join in the study. The interview between the researcher and teacher participants took place on June 5th, 2021. After interviewing teachers, the researcher began interviewing students selected and allowed by their teachers and parents. The researcher interviewed all selected participants about their perceptions regarding teaching and learning through inquiry, and the interview process ended on July 31st, 2021. In this process, the researcher employed semi-structured interview sheets interviewing the participants online at a convenient time. The period of each interview took about 40 to 50 minutes. Moreover, the researcher used Zoom Meeting for this interview and used Zoom's record function to record their voices. Then, the records were converted from voice to text (known as transcription), and this process was done by the researcher himself. Furthermore, before starting each interview, the researcher explained to them carefully the purposes of this interview and asked them permission to record their voices.

3.5 Data analysis

After the data was collected, the researcher tried to organize, transcribe, code, and categorize it. Moreover, to use the responses, the researcher chose the answers, which were the best to represent the data and comment on participants' perceptions regarding inquiry-based learning. The researcher quoted the responses, which were interesting, from the interview transcripts directly into finding sections. Furthermore, all of the data was analyzed case-by-case carefully and confidentially. Otherwise, the researcher compared the findings with previous studies, and then the researcher interpreted the meanings of the findings to answer the research questions.

3.6 Ethical considerations

This study was conducted by putting great attention on confidentiality and anonymity. All selected participants were informed about the study and was asked to give their consent to participate in it. To obtain valid consent, the study used an introductory statement at the start of interview to ask permission from the participants. This study would not ask for the name of participants, which showed anonymity in the study. Participants could skip questions or withdraw from the study at any time.

3.7 Summary of the chapter

This Chapter has reviewed in seven major sections: research design, sample size and sampling technique, research instrument, data collection procedure, data analysis, and ethical consideration, and limitation of the study. The researcher decided to use the qualitative research method for data collection and choose the purposive sampling method to pick up the participants. Then, the researcher selected six teachers of Physics—one of them is female. After that, the researcher received five student participants—three of them are females. Moreover, an instrument—online interviews—was used to collect data from June to July 2021. Later on, the researcher started to analyze the data by coding. The researcher also cared about ethical considerations that might affect the participants. Last but not least, some limitations were raised for information when the researcher conducted this study. The next chapter, chapter 4, will present the findings of this study.

CHAPTER 4: FINDINGS

In this chapter, the researcher will show six main findings as the following: (1) teachers' understanding regarding IBL and its levels; (2) how Physics teachers apply IBL in classrooms; (3) positive outcomes students obtain after learning through IBL; (4) positive outcomes teachers obtain after applying IBL; (5) challenges that teachers and students meet in the process of IBL in classrooms; and (6) teachers and students' perceptions regarding the use of IBL approach respectively.

4.1 Demographic information of participants

There were 11 participants who participated in this study. Among them, 6 participants were teachers and 5 participants were students. Regarding the teacher participants, one of them was female, and their age ranged from 24 to 28 years olds. Their teaching experiences were slightly different from each other, including relevant information as shown in table 7.

Table 7 Significant information of teacher participants

	Gender	**Age (year)**	**Teaching Experience (year)**	**Working at The High School (year)**
Teacher P1	Male	28	5	5
Teacher P2	Female	27	3	3
Teacher P3	Male	25	3	1
Teacher P4	Male	24	2	2
Teacher P5	Male	24	1	1
Teacher P6	Male	28	3	1

Regarding the student participants, three of them were teacher P1's students, and the rest were teacher P6's students. Their ages ranged from 16 to 18 years old, and 3 students were female (see table 8).

Table 8 Significant information of student participants

	Gender	Age	Grade	Teacher	Status
Student A	Male	16	10	P1	Outstanding
Student B	Female	16	10	P1	Outstanding
Student C	Female	16	10	P1	Poor performance
Student D	Female	17	11	P6	Outstanding
Student E	Male	17	11	P6	Poor performance

4.2 Teachers' understanding regarding IBL and its levels

The definitions of IBL

When the researcher asked a question about how they knew or heard about IBL, 2 participants mentioned that they first heard about it when they were studied at university, 4 mentioned that they first heard at the teacher training institute when they were trainees there. Then, all participants said that they had received more information about IBL at the selected high school. In addition, some of them mentioned that they heard about IBL more through social medias and their co-workers. In particular, they started teaching, 3 participants had opportunity to attend the training about IBL with national lecturers, so it made them got more understanding about it.

When the participants were asked to give a definition of IBL, all of them mentioned similarly that Inquiry-Based Learning (IBL) is a method that allowed students to be active in finding answers of what they are curious about or asked by their teachers. In this method, students are encouraged to use their critical thinking to discover knowledge by themselves through thinking, planning, creating. According to Teacher P1, “It is a methodology that is applied with students and make students active in their studies. When a teacher uses IBL, students start to think, participate… to be a part of the student-centered approach. IBL requires students to test or confirm any theory in Physics phenomena.” It was similar to Teach P3’s mention that inquiry-based learning is a study that tended to be the student-centered approach. It referred to a study that focused on main points brought by students, and the students played the role to do activities. Moreover, three teachers said that Inquiry–Based Learning refers to asking questions, and students take responsibility to find the answers of the questions from various sources or experiments.

The levels of IBL

Regarding the level of IBL, the responses were slightly different from each other. Four of the teachers were confident of showing their knowledge of the level of IBL. They said that IBL has four levels. In this case, two teachers mentioned levels of IBL ranging from 0 to 3, and a teacher thought that IBL ranked from level 1 to 4. Regarding the last teacher, he was not sure about that but he said it depended on students’ activities. In addition, a teachers admitted that he did not know about the levels of IBL. In table 9, it shows the information that all participants knew about the level of IBL.

Table 9 Teachers' understanding about the levels of IBL

	Teaching experience	**She/He mentioned that IBL has…**	**The levels of IBL range from…**
Teacher P1	5 years	4 levels	0 to 3
Teacher P2	3 years	4 levels	0 to 3
Teacher P3	3 years	4 levels	1 to 4
Teacher P4	2 years	4 levels	Not sure
Teacher P5	1 year	3 levels	Easy to difficult
Teacher P6	3 years	Not sure	Not sure

According to the table, Teacher P1 and P2 mentioned the same that IBL has four levels ranging from level 0 to level 3. They said that for each level of IBL, it is considered based on students' activities. For level 0, students just follow the activities that a teacher assigns. The teacher provides key questions, processes, or conclusions, whereas the students just read and tried to understand what the teacher has assigned for them. In this case, Teacher P2 expressed that level 0 cannot be considered IBL because all activities are teacher's activities.

Regarding level 1, Teacher P1said the teacher provides the process to the students. However, the students themselves explain the data of the experiments and make conclusions or inferences with reasonable proof. According to Teacher P2, it was related to inquiry questions. Most activities are starting with the teacher and students least participate.

For level 2, Teacher P1 mentioned that the teacher just provides a key inquiry question to the students, but students make the process, plan the experiment, measure, conclude, confirm or verify any theory by themselves. Teacher P2 said that there are some students' activities. The teacher just facilitates students with inquiry questions and planning and students find the answer and make conclusions.

For level 3, according to Teacher P1, the students do research, observe the phenomena. Then, they create problems, an inquiry question, and hypotheses. After that, they test the hypotheses, and make conclusions. In order words, this level reaches the scientific method. In this level, Teacher P2 argued that all activities are from students. The teacher just helps a little bit.

Regarding what Teach P3 mentioned about the levels of IBL, it was slightly different from Teacher P1 and P2's mentions. Teacher P3 He said that IBL has 4 levels ranging from level 1 to level 4. He said that level 1 is the easiest. It is called confirm inquiry, and it tends to be teacher-centered, which means that a teacher asked questions, students answer the questions. For level 2, which is structure inquiry, the teacher just provided questions to students, and students do research, analyze, and made a conclusion. In another level, which is guided inquiry, the teacher proposes a more extensive topic to the students, and the students do research, did experiments. For the last level, which is open true inquiry, it is like a thesis. Open-true means that students are able to learn, collect information, design content knowledge, do reflection, and made presentations by themselves. He included that important steps in IBL are (1): inquiry questions, (2): finding relevant information, and (3): sharing.

Regarding Teacher P4, he said that there are four levels. However, he did not remember the names of them. Anyway, he mentioned the levels depend on students' activities. If students have more activities like creating questions, it will be a high level.

Teacher P5 said that was not sure about levels of IBL. He said IBL has 3 levels based on what he had known. The three levels of IBL are easy, medium, and difficult. Regarding the easy level, for example, a teacher provides questions and students just find the answer. They do not need to experiment. For the medium level, the student need to conduct a little experiment to support or answer a proposed question. The third one is the difficulty level, which is like the scientific method. It has to follow step by step, and it should have an experiment, materials specifically.

Regarding Teacher P6, he admitted that he did not know about it whether he forgot or the high school had not provided this information to him.

4.3 How Physics teachers apply IBL in classrooms

The result showed that all the participants said the same about the process of using IBL, which was starting inquiry questions introduction. In this step, the participants explained how to introduce an inquiry question indifferently based on their experience. Four of them raised the process of using IBL in experiments. A teacher shared the experience of using IBL in the online learning context, and another participant admitted he hardly ever used it.

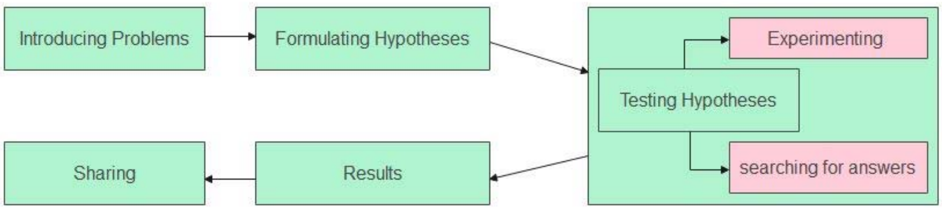

Figure 3 IBL process in classrooms

To characterize the teacher's approach to IBL using the IBL levels in figure 3, the data was collected for each of the abilities required: Problem/Question (Introducing the problems, Formulating the Hypothesis), Procedure/Method (Testing hypotheses, or experiments, or finding answers), and Solution (Results, Sharing). Teacher responses are summarized in table 10, which is based on table 6 (Grady, 2010). The teachers' answers are summarized for each ability.

Table 10 Summary of teachers' answers, based on the table 6 (Grady, 2010)

Level of scientific reasoning tasks Least complex → Most complex				
	Pre-inquiry	**Developing Inquiry**	**Proficient Inquiry**	**Exemplary Inquiry**
1. PROBLEM: Introduce the problem Identify questions and concepts that guide scientific investigations.				
Teacher levels	P4, P5, P6	N/A	P1, P2, P3	N/A
2. PROBLEM: Formulate Hypothesis Identify questions and concepts that guide scientific investigations.				
Teacher levels	P6	P2, P3, P4, P5	P1	N/A
3. PROCEDURE: Testing hypotheses, or experiments, or finding answers Designing and conducting the research investigation.				
Teacher levels	P4, P6	P5	P1, P2, P3	N/A
4. SOLUTION: Results Formulate and revise scientific explanations and models using logic and evidence.				
Teacher levels	N/A	N/A	P1, P2, P3, P4, P5, P6	N/A
5. SOLUTION: Recognize and analyze alternative explanations and models.				
Teacher levels	N/A	N/A	P1, P2, P3, P4, P5, P6	N/A
6. SOLUTION: Communicate and defend a scientific argument.				
Teacher levels	N/A	N/A	P1, P2, P3, P4, P5, P6	N/A

Table 11 Teacher Levels of inquiry, based on the data (adapted from (Fay & Bretz, 2008)). Abbreviations: P# teacher number; p+ partial student construction with little teacher input; p- partial student creation with teacher input.

Table 11 Teacher levels of inquiry

Level: Teachers	Problem/Question	Procedure/Method	Solution
Level 0:	*Provided to students* P4, P5, P6	*Provided to students* P4, P5, P6	*Provided to students* N/A
Level 1:	*Provided to students* P1, P2, P3, P4, P5, P6	*Provided to students* P1, P2, P3, P4, P5, P6	*Constructed by students* P1, P2, P3, P4, P5, P6
Level 2:	*Provided to students* P1, P2, P3, P4, P5	*Constructed by students* P2, P4 Partial P1p+, P3p+, P5p-	*Constructed by students* P1, P2, P3, P4, P5
Level 3:	*Constructed by students* Partial P1p+*, P2p-, P3p-	*Constructed by students* Partial P1p+, P2, P3p+	*Constructed by students* P1, P2, P3

*Confirmed by student

Introducing the problems

According to Teacher P1, he asked relevant questions to students before entering the inquiry question. He facilitated students to understand the questions one by one, and then he helped students create an inquiry question. In this case, Teacher P3 asked inquiry questions about the topic and mentioned Flipped Classroom that he posted materials or documents for students to read or watch before starting the class. He described the process of using IBL shortly. Regarding Teacher P5, he introduced a problem to students. He called phenomenon introduction. Then, it was inquiry questions. Teacher P4 described shortly that the first step of IBL is objective, and inquiry questions come after.

Regarding Teacher P2, she raised an example of the process of using IBL in her classroom in the online context. First of all, she provided a picture of a resistor to students. Then she proposed questions to students about what the picture was and how to read color codes.

Formulating hypotheses

In this part, three participants mentioned hypotheses formulation after inquiry questions. With hypotheses, the teachers helped facilitate students to create them, as said by Teacher P1, "To make hypotheses, students have to think of three elements: dependent clause, independent clause, and hypotheses. I help them to evaluate their hypotheses based on the above components. The best hypothesis contained three conditions: *If*, *Then*, and *Because*. In a hypothesis, three elements and three conditions came together."

Testing hypotheses, or experiments, or finding answers

In this step, students work in groups in order to test their created hypotheses or find the answers. According to Teacher P1, P3, P4, and P5, the process of this activity starts with conducting experiments. Teacher P1 said that, "In this step, I ask students to design the plan of the experiment by drawing diagrams based on their perceptions in each group. I rarely provide any plans for the experiments to the students. For level 1, I provide the process of the experiments to them. For level 2, I let them think based on their perception and understanding because some experiments can conduct in different ways, but they release the same result. In this case, I as just facilitator only."

According to Teacher P2, she did not mentioned experiment process, but she raised the way she used with students for finding answers. She wanted students to think and discuss in groups before starting the class. The students found the answer through the internet, books, etc.

Results

After experiments, students discuss with their groups about results collected, make analysis and how to report them. According to Teacher P1, "a result can release as qualitative or quantitative based on the objective of the topic. If the data receive was quantitative, students write it down into the chat in the worksheet. If there are some calculations, they are required to do. Then the students analyze the result, and they draw diagrams or graphics if possible." It is similar to the mentions of Teacher P2, P3, P4, and P5 that students take more activities with the result they collected.

Sharing

All teachers mentioned the same that students have to share their findings whether their answers respond to the inquiry questions or not. . In this step, Teacher P1 said that students compare the results with their hypothesis. Then team leaders present the results and share them with classmates. He asks students to check whether the result responded to their hypothesis or not. He also included, "I can spread STEM, which is related to real-life application. In some cases, I assign projects for students asking them to find theory applications from their studies in their real life."

4.4 Teacher and students' roles in IBL

The result showed that all teachers were responsible for providing documents, problems, questions, instruction, and facilitations. Teacher P4 added, "My roles in IBL depend on the level of it. For the first start, I initiate activities, including the experiment process. I have made an example for students, and then I have motivated them to do it by themselves."

Regarding students' roles, they followed teachers' guidance to find answers and were more active in IBL. According to Teacher P1, students do activities to find answers and knowledge by themselves. That might be a support from Teacher P3, stated that, "Student take more activities, tending to reach a student-centered approach. They are so busy in their studies in IBL."

What the teachers mentioned was consistent with the responses from student participants. According to Student A, which is Teacher P1's student, he said that his teacher facilitated with group settings, hypothesis formulation, experiments, worksheet, and other problems. He also added, "Teacher's activities and students' activities remain the same. The teachers has made an example for students, and the students have just followed him. I think that students should have more actions."

4.5 Positive outcomes students obtain after learning through IBL

4.5.1 In the process of IBL

Responses from the teachers

In this finding which is related to the third research question, the researcher used online interview to collect data. The responses from the teacher remained the same that students had developments in Physics content knowledge, participation, working as groups, and research. Teacher P2 felt surprised with some answers that were better than her prepared answer. The students were good at doing research on the internet to find the answer. Moreover, Teacher P3 included, "Students learned to do research using technology in connection to STEM Education." In addition, Teacher P5 expressed students' interest in learning through IBL. He said that students felt happy because they had discussed, exchanged ideas, played roles, and participated actively.

Regarding basic science process skills, students' improvement on both basic knowledge skills and advanced differed from a teacher to another teacher. Two teachers said that students were good at observation and measurement. According to Teacher P2, P3, P4, and P5, students' abilities of observation, measurement, and using tools depend on their frequency of doing them, levels of lessons, and their basic knowledge and foundation.

Moreover, students also have improvements on creating hypotheses, drawing a conclusion, and providing feedback, according to all responses. Teach P1 added, "Most students developed faster, whereas only a few students still had some problems with these skills." Teacher P4 and P5 argued that student's ability to make conclusions depend on their levels of knowledge and topics.

Regarding advanced science process skills (or integrated science process skills), all responses from the participant's mentioned similarly that students are not good at drawing diagrams and explaining the diagrams or charts. Only clever, students can do it, said Teacher P3, and it work best for high grade students, added Teacher P5. Moreover, all teachers mentioned that students tend to use inductive rather than deductive reasoning.

Responses from the students

The students' responses showed that all students had more understanding of content knowledge, and they tended to like learning Physics. However, outstanding students had more improvements in basic science skills and advanced science skills. Four Students mentioned their improvements on teamwork and communication. According to Student A, students increase their curiosities through inquiry. When they start to find their answers, they will have more understanding the lessons rather than repeating word by word. Student B, C and D mentioned that they have confidents when doing experiments.

Regarding basic science skills, which are observing, measurements, and forming hypotheses, most students said that they could do observing. However, three of the students mentioned errors about measurements, as Students D said, "…because the inaccuracy of measurement might occur in the experiments." Student A and D thought that they could form hypotheses; however, the others did not think that they could perform well with it.

Regarding advanced science skills, the researchers received two response from all students that they could draw diagrams and explaining them. For other students, like student A, he did not express his ability to draw and explain diagrams due to leaning online. It is similar to Student C's mention, there were not many activities in the worksheets. According to student E, he could not do them unless there was some explanation from the teacher. In addition, the students describes their ways of solving Physics problems in a form of deductive reasoning.

4.5.2 After the process of IBL

In this finding which is related to the third research question, the researcher used online interview to collect data. The result showed that students had developments and improvements after being taught through IBL. All teacher participants said that students developed their Physics content knowledge, research skills, and teamwork. In addition, Teacher P2 added that students increase their thinking, and they had responsibility, independence, and confidence. It is similar to what Teacher P3 mentioned, students' development like decision and confidence. He also included that students can connect the lesson to real-life applications. For example, students learn Thermal Expansion of Solids when heated. Then, they observe an application of thermal expansion showing that a sufficient amount of gap is provided between railways track joined by plates to avoid bending and causing fatal accidents. According to Teacher P4, students also develop their skills of using experiment tools, and Teacher P5 included that students improve their ICT skills.

Responses from students

The researcher asked the students about their improvements after learning through experiments or IBL. The result showed that students remembered the lessons more clearly when they had learned them through experiments. Three responses, to the question were that they gained new knowledge and start liking physics the most. One student mentioned that he felt satisfied with working as a group and taking the role of a team leader. It was because he could share his knowledge with the team and learn from the team as well.

Similarly, Student B, C, D and E, mentioned about the importance of teamwork that help them in leaning with experiments. Moreover, all students mentioned about their increasing researching habits, and one of two of them had explored more in real-life applications.

4.6 Positive outcomes teachers obtain after using IBL

4.6.1 In the process of IBL

In this finding, all participants had improved in student management, mastered the content lessons, and had leadership skills. According to Teacher P1and P3, their teaching techniques were interesting from his students, especially when they had videos, simulations, or exact experiments. Moreover, teachers increase their research habits, as said by Teacher P2, "If the teacher do not provide students with appropriate responses, they will have no more trust in their teacher. So, the teacher must find the answer before students and read documents and sources as much as possible." This seems to be supported by Teacher P5 and P3, stated that they changed from teaching styles without experiments to well-prepared teachers with experiments.

4.6.2 After the process of IBL

The result showed that all teachers mentioned their improvements and developments in different aspects. There were five teacher who said that they had improvement on content knowledge, four of them gained research skills, and two participants mentioned technology and ICT improvements. Moreover, Teacher P1 implied that his workplace is one of the factors that had helped him use IBL.

Regarding motivation, some of them mentioned support from student guardians. The parents follow up with students, and they admire teachers when the students improve their studies. The teachers also receive motivation from the school principals through Profession Learning Community (PLC).

4.7 Teachers' challenges in the process of IBL in classrooms

4.7.1 Before the process of IBL

Challenges

The result showed that all participants had similar issues with experiment tools. According to Teacher P1, "I have problems with some topics of experiments. Of course, they are interesting, but they are hard in writing worksheets!" Here were the topics that were to write worksheet: The Second Law of Newton (difficult to collect the data), Friction forces (difficult to calculate a coefficient of friction), Projectile motion (difficult to define initial velocities), Free fall (high incorrect data rates), and The First Law of Thermodynamics (difficult to measure energy). This seems to be supported by Teacher P3and P4 who said that some topics are extensive. Similarly, Teacher P2 included, "some materials cannot find in the school." For example, time trackers, rough boards, air-pump machines, black ink, etc. as mentioned by Teacher P1. In addition, forming inquiry questions is another issue. The response from Teacher P6 was that felt worried that his questions did not support his lesson objectives. This is not much different from Teacher P5's mention, which is a problem with problem introduction of students.

Solutions

To deal with topics of experiments, some teachers have to do more research included the experiment process and tools. They need helps from other teachers or technical teams on how to write it, to make students be able to do it, to write its lesson plans, and to prepare activities for teaching. Regarding shortage of Experiment tools, they used Phet Simulation software instead. They even make request of supporting teaching materials to the school or stakeholders.

4.7.2 In the process of IBL

Challenges

The result showed that the some of the participants had similar issues with experiment failure and student management. According to Teacher P4 and P6, one was that the experiments did not work when students had been practicing. Two teachers mentioned the cut-off electricity when experiment process. Moreover, four teachers complained that they had problem with student management. Teach P1 said, “Some students play with experiment tools and do not focus on experiments.” Teacher P3 added, “There are so many students in the classroom…I find hard to control them.” Time constraint is also a problem that was raised by three participants.

Solutions

To deal with naughty students, two teachers mentioned the same that they came closer to those students and approach them. Regarding experiment failures, they approached the students and facilitated them. Talking about time constraints, the responses from participants were to teach experiment lessons with 2 hour allowed time.

4.7.3 After the process of IBL

Challenges

The result showed that the participants had issues differently from each other. Some teachers even said they did not have any problems at this stage. According to Teacher P1, he said that sometimes he could not receive the experiment report from all students because some groups had failed to experiment. It had affected his feedback and reflection. Teacher P2 added that sometimes she received error data after the experiment. Moreover, two teachers mentioned about broken experiment tools by students after the experiments. Teacher P6 admitted that he had problems with test design, similar to Teacher P1, stated that he had problem of the IBL techniques like asking questions after the experiment. When he had asked deep questions, the students could not answer them.

Solutions

To deal with experiment report and incorrect data, the teachers had to think and check again. They also discussed with their co-workers about the problem. Similarly, the solution to test design and questioning techniques was that the teachers needed enough time to create them and recheck the questions.

Regarding the safety of the experiment, the teachers recommended students be careful with experiments. For example, Teacher P1 asked students to wear gloves or use fabric and set roles clearly during the experimental procedure.

4.8 Students' challenges in the process of IBL in classrooms

4.8.1 In the process

Challenges

The result showed that outstanding students had similar problems: lack of teamwork collaboration and time management. Regarding poor-performance students, they seemed not to have any concerns. According student A, B and D, Some members were not inactive, and some students had not collaborated in the group. Student A explained the time management issues. He said that in 45 minutes of learning for a class, he had had around 20 to 30 minutes to start experiments after the teacher's explanation. Moreover, some discussions in the group would take more time. This problem had made his team rush to write a report about the experiment. Student B also said that she was scared of experiments with electricity. Two students mentioned that they had problem with hypothesis formulation.

Solutions

Student A, B and D seems to have the same idea that they dealt with lack of participation problem by motivating their members to collaborate. According to Student A, "I explain the importance of teamwork to them and encouraged them to speak up. I explain more if they don't understand any part. If they don't share ideas, I don't know whether they understand or not. If they participate with the groups, I can help them."

Regarding time constraints, what the students can do with this is to be ready with experiment without delaying time. Based on what Student A mentioned, after receiving a task from the teacher, he had suddenly met his members and assigned roles for them. To be on time, he has asked the members to write their ideas on paper and show them all together. Then he had allowed them to explain ideas, and the group had discussed the ideas.

To deal with formulating hypotheses, Student B said that she needed to understand the relation variables through teaching explanation so that she could make them. Another solution, she could take time to research. According to Student A, he had asked the team leader to change his role. He had become a note-taker instead.

4.8.2 After the process

In this finding, which is related to the fourth research question, the researcher used the online interview to collect data. The result showed that students seemed not to have any problems unless they did not understand the lesson or homework.

4.9 Teachers' perceptions of IBL in Physics course

The result showed that the participants had positive thinking about IBL. Based on Teacher P1's perception, Inquiry-based learning is an effective method in constructivist teaching and learning, as he said, "IBL fosters Students to be active and develop their knowledge of Physics phenomena deeply. They remember the Physics formula and explore physics phenomena." He also included, "Students want to research and create projects to solve problems in their society. They also start to use their critical thinking about Physics' real-life applications." This means that IBL encourages students to use their knowledge and apply it in their real-life application and solving problems that happen in their society.

Moreover, according to Teacher P3, Cambodia will be like Singapore if teachers can apply IBL in the classrooms. Students' learning in IBL is the student-centered approach. They learn to have a responsibility, research and making a decision. It is really good method. In addition, Teacher P5 expressed that IBL is good for students to improve their abilities in learning. Moreover, it changes from the traditional method to learn finding answers, test experiments and verify what teachers have just said by students. Teacher P6 seemed to agree with that as he mentioned, "IBL is significant to student learning, and it is good among other teaching methods. It is a method of collaboration learning."

Through IBL, teachers improve and extend their knowledge through research, thinking, and analysis. It works not only with teachers but also with students for development and improvement. Two participants showed enthusiasm about IBL as Teacher P2 said, "Teachers themselves develop their ability and knowledge. They gain more flexibility, intelligence, and critical thinking."

Interestingly, According to IBL, students are motivated and oriented at science, engineering, or artificial intelligence. Before they study at universities, they have already had basic skills like teamwork, research, and doing the assignment, based on Teacher P1's mention.

Lesson suitability with IBL

All participants mentioned the same that IBL is really suitable to be used in upper-secondary classrooms. Regarding physics lessons that teachers can teach using IBL, Teacher P1 said IBL can be for all topics. But, experiment topics, finding formulas and principles, and theory confirmations were the best for students to learn through IBL. Teacher P3 included, "IBL is quite suitable to be used in Physics at the upper secondary level, especially for Electricity and Thermodynamics parts. The reason is that it is easier to conduct experiments than other parts like Waves and Mechanics." Other teacher also supported that IBL worked best with experiment lessons. However, Teacher P2 claimed that not experiment topics in Physics must use IBL all the time. The teacher can use other methods with lessons regarding content knowledge. It depends on teachers' flexibilities to crate inquiry questions and how to encourage students to be able to answer the questions.

In addition, all teachers seems to be willing to share this method to other teachers because it made students interested in this course, and they could use their knowledge in their real-life applications. The teachers themselves will be clear with this method when sharing. Teacher P1 also motivated Cambodian teachers to use IBL in their teaching as much as possible. He said that all teachers get trained at the same teacher training institute; therefore, they have received the same teaching methodologies. It is significant for education and developing human resources in our country.

Suggestions

The following are some suggestions that were raised by teacher participants:

- School principals and the Ministry of Education should focus their attention on the IBL method by providing enough teaching materials, finding supporting partners on teaching methodologies, and teaching material management so that science teachers can use IBL effectively.
- The schools' principals should motivate teachers to use IBL as much as possible.
- Schools should have classrooms for various subjects like physics classrooms.

- There should be enough school amenities teaching aids, and experimental tools.
- Teachers should follow the steps IBL so that students can develop knowledge by themselves. They learn to research a lot, whereas teachers just guide them only.
- Teachers should have extensive knowledge and experience before using IBL. They try to use IBL as much as possible. When they apply IBL in their teaching, it will not make them bored with their subjects, and they can develop the knowledge more widely. Also, their students will be happy to study, explore, and research various phenomena.
- Teachers should learn and research about IBL. Then they share experiences to extend the concept of IBL extensively for developing education.

4.10 Students' perceptions of IBL in Physics course

The result showed that all students were satisfied with learning through experiments in the IBL context. From this action, they remembered and gained more understanding about Physics and encouraged them to like learning Physics course. According to Student A, students can study as groups. They can discuss, collaborate, and exchange ideas. Moreover, students can learn, find answers, and research by themselves. They get various information from many sources, and the information was significant for developing inquiry skills. Student D included, "learning experiments is good because students can have questions to teachers, and the teacher know how well students understand lessons. Moreover, I can practice experiments, writing reports, and feedback. This help me understand the process clearly".

However, there are some negative effects if using IBL. According to Student A, he focused on teamwork. Each member have different ideas. The disagreement might occur in the team.

Suggestions

The following are some suggestions that were raised by student participants:

- All students should participate in teams when the teacher assigns any tasks. Their participation with ideas or activities can help them develop and improve their studies and knowledge. Sharing ideas and discussion could make the teamwork active.
- Students must pay attention and take notes of what teachers have explained.

The next chapter, chapter 5, will present discussion between the result obtained and the literature review in this study.

CHAPTER 5: DISCUSSION

This chapter, discusses the summary of the major findings from the interviews as presented in Chapter 4 against the research questions, particularly looking at teachers' understanding regarding the levels of IBL, how Physics teachers apply IBL in classrooms, positive outcomes teachers and students obtain through IBL, challenges that teachers and students meet regarding the use of IBL, and teachers and students' perceptions regarding the use of IBL approach. The discussion is taken through literature review.

5.1 Teachers' understanding regarding IBL and its levels

The result showed that all teachers mentioned similarly that Inquiry-based Learning (IBL) was a method that allowed students to be active in finding answers of what they were curious about or asked by their teachers. The students were encouraged to use their critical thinking to discover knowledge by themselves through thinking, planning, creating. Similarly, Hussain et al. (2011) stated that inquiry enables students to conduct observations, come up with questions, examine instructional materials and other sources of information. Moreover, they use tools to collect, analyze, interpret data, propose answers, explain, make predictions, and discuss the results. Other researchers (Fernandez, 2017; Jong & Joolingen, 1998; Keselman, 2003; Margus Pedaste et al., 2012) also mentioned IBL in similar ways that students play an active part in the process of knowledge construction, and they works as professional scientists to discover new knowledge.

However, regarding the level of IBL, the responses were slightly different from each other. Four of them were confident of showing their knowledge of the level of IBL. They said that IBL had four levels. In this case, two teachers mentioned levels of IBL ranging from 0 to 3, and a teacher thought that IBL ranked from level 1 to 4. Regarding the last teacher, he was not sure about that but he said it depended on students' activities.

According to Banchi and Bell (2008) and Tafoya, W.Sunal, and Knecht (1980), The inquiry-based learning has four levels as shown in the table below:

Table 12 Levels of inquiry on teacher agency and learner autonomy (Tafoya, Sunal, et al., 1980)

	Level 1 Confirmation Inquiry	**Level 2 Structured Inquiry**	**Level 3 Guided Inquiry**	**Level 4 Open/True Inquiry**
Problem	Teacher-led	Teacher-led	Teacher-led	Student-initiated
Procedure	Teacher-led	Teacher-led	Student-initiated	Student-initiated
Solution	Teacher-led	Student-initiated	Student-initiated	Student-initiated

Regarding the responses from the four teachers who explained the four levels of IBL, they match with what the previous researchers stated above. This means that those teachers understood the concept of inquiry-based learning clearly. However, two of them said that IBL ranked from level 0 to level 3. This is a difference in identifying the levels of IBL where Tafoya, W.Sunal, et al. (1980) and Banchi and Bell (2008) mentioned. In the Cambodian context, teacher training institutes depends on Fay and Bretz (2008) (see table 13) to identify the lowest level of IBL as level 0, whereas the highest level was level 3 (MoEYS, 2018b). Therefore, there is no doubt that teachers who were trained from Cambodian teacher training institutes said about levels of IBL ranking from 0 to 3 unless they had researched more about that from foreign documents.

Table 13 Levels of inquiry rubric (Fay & Bretz, 2008)

Level	Problem/Question	Procedure/Method	Solution
0	Provided to students	Provided to students	Provided to students
1	Provided to students	Provided to students	Provided to students
2	Provided to students	Constructed by students	Constructed by students
3	Constructed by students	Constructed by students	Constructed by students

Another teacher unsurely said that IBL had three levels, ranging from easy to difficult. He has one year of teaching experience. Moreover, when he was trained at the teacher training institute, the Covid-19 outbreak happened. All schools in Cambodia were closed, and he said that he had not known much about IBL. The last teacher did not know about the level of IBL because he had not paid much attention when he was at the teacher training institute. Moreover, he had hardly ever used it in his three-year teaching experience.

5.2 How Physics teachers apply IBL in classrooms

All Physics teachers said the same about the process of using IBL, which was starting inquiry questions introduction. In this step, the teachers explained how to introduce an inquiry question indifferently based on their experience. Four of them raised the process of using IBL in experiments. A teacher shared the experience of using IBL in the online learning context, and another participant admitted he had hardly ever used it.

The finding showed a difference from Tandon and Fukao (2015) and Pich (2017), saying that Cambodian teacher trainers mostly use a teacher-centered teaching approach instead of a student-centered teaching approach, and they fail to teach meaningful content mastery. Perhaps their finding focused on teacher trainers of social science subjects or teachers of English, and the teacher trainers did not apply inquiry-based learning in classrooms very often.

Regarding the teachers who described how they applied IBL in experiments, a teacher with the most teaching experience explained clearly from the first step to the end. He started with proposed relevant questions to students so that they could make an inquiry question. Then he helped students to create hypotheses by thinking of three elements of good hypotheses: *If*, *Then*, and *Because*. After that, he facilitated students with the experiment process, after the process (result and analysis), and conclusion with sharing at the end. This process was similar to other findings from many researchers. According to Friedler et al. (1990), Veermans (2002), M. Pedaste and Sarapuu (2006), and Mäeots et al. (2008), scientific inquiry processes are not far different, starting from problem identification, research question formulation, hypothesis formulation, experiment planning, carrying out an experiment, analysis, and interpretation of results, drawing conclusions, and presenting the findings.

Talking about a female teacher who had applied IBL in her online classes, she had not used it with experiments. In contrast, she described her IBL teaching like constructing knowledge in social science subjects. She started with providing problems to students, including relevant and inquiry questions. Then the students worked in groups to find answers as the responses to those questions. After that, they shared what they had found with the class, and the teacher just facilitated students and corrected students' mistakes when they found wrong answers. According to Hampshire College, McMaster University in Canada, They have been teaching inquiry for over 20 years. They teach students to be self-directed learners and have more responsibility for determining what they need to learn, identifying resources and how best to learn from them, using resources and reporting their learning, and assessing their progress in learning (McMaster University, 2007 as cited in (Spronken-Smith, 2012)).

5.3 Teachers and students' roles in IBL

In inquiry learning, teachers were responsible for providing documents, problems, questions, instruction, and facilitations. Regarding students, they followed teachers' guidance to find answers, discover knowledge, and take more activities than the teachers. In Inquiry-based learning (MoEYS, 2018b; The Teacher Training Department of the Ministry of Education, 2016), students are motivated to work with their peers or classmates in the process of knowledge discovery rather than being told directly by the teachers. Teachers' roles in IBL were not to provide knowledge to students. Instead, they help facilitate students finding answers and knowledge the students themselves. According to Fernandez (2017), students who learn through inquiry take an active part in finding and constructing knowledge. Moreover, Jong and Joolingen (1998) said that learners participated actively with responsibilities for discovering new knowledge in IBL.

5.4 Positive outcomes students obtain after learning through IBL

5.4.1 In the process of IBL

In this finding, the result from the teachers showed that students had developments in Physics content knowledge, participation, working as groups, and research. The student participants said that they had more understanding of content knowledge, and they tended to like learning Physics. It is consistent with the finding of Rocard et al. (2007) that IBL gives students opportunities to develop a wide range of complementary skills such as group work, writing in verbal expression, the experience of open-ended problem-solving, and other cross-disciplinary abilities. Moreover, Walker (2015) also stated that IBL helps students understand and remember content knowledge of science better, and they find math and science subjects more interesting and exciting (Dorier & Maaß, 2012).

Regarding students' improvement on both basic science process skills and advanced differed from a teacher to another teacher. Some teachers said that students had basic science-skill improvements like observation, measurement, creating hypotheses, drawing conclusions, and providing feedback. However, other teachers argued that the correctness of those abilities depended on the level of content knowledge and students' competencies. It was similar to the responses from the students. They described their basic process skills in science reasonably with status. According to Karamustafaoğlu (2011), "basic science process skills are observing, classifying, measuring, and predicting. These skills provide the intellectual groundwork in scientific inquiry, such as the ability to order and describe natural objects and events."

In the finding of students' advanced science skills, their teachers said that most students were not good at those skills like drawing diagrams and explaining them. However, they could formulate hypotheses and did experiments acceptably. According to Karamustafaoğlu (2011), integrated Science Process Skills include identifying and defining variables, collecting and transforming data, constructing tables of data and graphs, describing relationships between variables, interpreting data, manipulating materials, recording data, formulating hypotheses, designing investigations, drawing conclusions, and generalizing. These abilities are the terminal skills for solving problems or doing science experiments.

5.4.2 After the process of IBL

After students attend IBL classes, the responses from the teachers were that students develop content knowledge, research skills, and teamwork. They increase their thinking, responsibility, independence, confidence, and making a decision. Moreover, students can connect the lesson to real-life applications and develop their skills of using experiment tools and technologies. According to students themselves, they remember lessons more clearly when they learn them through experiments. They gain new knowledge and start liking physics. Moreover, students understand the importance of teamwork and improve leadership skills. In particular, students increase their researching habits and explore more real-life applications.

Inquiry-based learning helps students promote critical thinking skills and the development of key competencies (Hattie, 2009). Rocard et al. (2007) found that the IBL approach may be an effective way to grow students' self-confidence and participation in scientific activities. The same researcher also stated that IBL gives students opportunities to develop a wide range of complementary skills such as group work, writing in verbal expression, the experience of open-ended problem-solving, and other cross-disciplinary abilities. Dorier and Maaß (2012) included that IBL affects students' willingness to continue studying scientific disciplines and getting involved in scientific careers. Other researchers seems to support with this finding, like Rakow (1986) and Walker (2015). Inquiry learning helps students understand how scientists generate knowledge and how the current scientific knowledge is developed and produced. Students will create a more balanced and realistic perception of science, its nature, and its way to create and develop.

5.5 Positive outcomes teachers obtain after using IBL

5.5.1 In the process of IBL

IBL improves not only students' knowledge, skills, and attitude but also their teachers. Through IBL, teachers improve in student management, master the content lessons, and have leadership skills. Moreover, they can draw students' attention and attraction from their teaching techniques. When they have videos, simulations, or exact experiments, students are interested in those activities. In addition, IBL fosters teachers to increase their research habits.

Melušová and Šunderlík (n.d.) raised supporting actions for teachers about the principles of IBL pedagogies. These include direct supporting instructions (insight, motivation, and encouragement) and indirect supporting instructions (supportive groups) to teachers. The finding seems to agree with Melušová and Šunderlík (n.d.) based on some reasons raised by a participant mentioning Professional Learning Community (PLC) as motivation they received.

5.5.2 After the process of IBL

The finding showed that all teachers mentioned their improvements and developments in different aspects. Most of them had improvement on content knowledge, and research skills. Two teachers mentioned technology and ICT improvements.

5.6 Challenges that teachers meet in the process of IBL in classrooms

5.6.1 Before the process of IBL

The result showed that, while IBL promotes benefits to students and teachers, there are some concerns from teachers mentioning. The participants had similar issues with limited understanding of IBL, experiment topics, experiment tools, shortage of teaching aids or materials. According to Anderson and D. (1996), the barriers of the use of constructive approaches in teaching include technical problems like limited teaching ability of teachers and challenges of assessment. Rakow (1986) and Walker (2015) also found that lack of resources and difficulty of assessment are parts of barriers teachers normally face when applying IBL in the classrooms. In Cambodia, the limitations of significant teaching aids such as textbooks, libraries, electricity, laboratories, teaching materials, and teacher's guides, reference books for teachers, tables, and school buildings are still hindering education improvement and development (MoEYS, 2018a; Ren & Kosal, 2016).

5.6.2 In the process of IBL

The result showed that the some of the participants had similar issues with experiment failure, electricity cut, student management, large classes, and time limitation. It is consistent with Lawson (2000) that common issues novice teachers face in teaching IBL. These include lack of students' participation in activities like participation enough in inquiry, no care and no see the inquiry as relevant to their lives, lack of background knowledge for inquiries, bad attitude and are disruptive, no want to think for themselves. Moreover, Rakow (1986) and Walker (2015) also mentioned that Inquiry-based science takes more time and some inquiry-based lessons might not work; therefore, teachers might lose some controls in their teaching.

5.6.3 After the process of IBL

At this stage, the researcher received a few complaints from teacher participants what they still faced after teaching IBL. These include late experiment data, inaccuracy in data collected, broken experiment tools and materials, and assessment. In the finding conducted by Anderson and D. (1996) also raises challenges of assessment as a part of the barriers of the use of constructive approaches in teaching. The finding seems to be supported by Rakow (1986), Yoon et al. (2012), and Walker (2015) that difficulty of assessment, including problems with safety and time consuming might occur in IBL classrooms.

5.7 Challenges that students meet in IBL classrooms

The result showed that outstanding students had similar problems: lack of teamwork collaboration, time management, hypothesis formulation, and safety. This finding is consistent with statements from many researchers. Lawson (2000) states that some students do not participate enough. They do not care and see the inquiry as relevant to their lives. Rakow (1986) and Walker (2015) include that there will be a need for enough time if teachers wish to use IBL in classrooms. Moreover, some activities in IBL might not be safe for students, like experiments with electricity. Teachers must be careful and make sure they provide instruction clearly before experiments. The same researchers also mention that only ability students can learn through inquiry. Lawson (2000) added that some students lack of background knowledge for inquiries. Therefore, it requires resistance of both teachers and students to run inquiry classrooms in process.

5.8 Student and teachers' perceptions of IBL in Physics course

The result showed that the participants had positive thinking about IBL. Inquiry-based learning is an effective student-centered method in constructivist teaching and learning. Students learn to have a responsibility, group work, research, discussion, and making a decision. It changes from the traditional method to finding answers, test experiments, and verify what teachers have just said by students. It is similar to a mention by Mathematics (2016). Inquiry-based learning helps students learn by participating in activities that reinforce physics concepts. It works by showing students with authentic questions, observations rather than showing concepts taught by teachers. This process fosters the active engagement of students, increased learning, and retention of ideas.

According to IBL, students are motivated and oriented in science, engineering, or artificial intelligence. Before they study at universities, they have already had basic skills like teamwork, research, and doing the assignment. This seems to support Bredenberg (2018), the Ministry emphasizes the importance of critical thinking that makes students need preparation for future employment. Employers need employees with analytical thinking and decision-making as skilled and semi-skilled work.

Cambodia will be like Singapore if teachers can apply IBL in the classrooms. Moreover, teachers improve and extend their knowledge through research, thinking, and analysis through IBL. A suggestion from Dickinson et al. (2011), Cambodian pre-service teachers are required to shapes their future practice of teaching through inquiry whether they experience in this constructive approach.

The next chapter, chapter 6, will present conclusion, limitations, and recommendations in this study.

CHAPTER 6: CONCLUSION, LIMITATION, AND RECOMMENDATION

In this chapter, the researcher showed a summary of the key findings, limitations of the study, and recommendations for stakeholders and further studies.

6.1 Conclusion

This study was conducted to search for understandings of the IBL characteristics, which support science education and teacher-student relations. In addition, the objectives of this study were to discover positive outcomes teachers and students obtain through IBL and its challenges. Importantly, the researcher expected to explore teachers and students' perceptions regarding the use of IBL approach.

The findings of this study showed that all teachers of Physics interviewed had heard of inquiry-based learning; however, their understanding of the IBL concept depends on their experience of teaching Physics. In other words, the teachers who had teaching experience for many years understand more about the IBL concept. It includes the characteristics of IBL, levels, implementation in classrooms, and roles of teachers and students in IBL classrooms based on the literature review, which describes those relations.

Even though the teachers have an unequal understanding regarding IBL, they have a similar understanding of IBL meaning, which focuses on students' activities. Students have a responsibility to find answers or construct knowledge by themselves through various ways like reading books or documents, visiting libraries, researching on the Internet, or conducting scientific experiments. When the students receive their answers, whether their results respond to their inquiry questions or not, they have to share their results of findings with their classmates or the whole class under facilitation from the teachers. It means that teachers are not supposed to take roles in finding answers in the inquiry-based learning approach. They mainly facilitate, help, guide, consult, or scaffold students to construct knowledge through finding responses to their inquiry questions. In short, the teachers try to encourage students to have more activities, whereas the teachers themselves reduce their actions to be the least in IBL classrooms.

According to this study, Physics teachers at the selected high school mostly applied the IBL approach with level 1 or 2 of inquiry in case IBL ranges from Level 0 to 3. In other words, they mainly used IBL with level 2 or 3 if IBL is considered from level 1 to 4. The teachers argued that students' activities in the first level of IBL seem to be less and follow all teachers' instructions. In addition, regarding the last degree of IBL, the teachers consider it the most difficult one. Only students with high competencies reach this level. The findings of this study pointed out that the teachers take roles to provide problem introduction to students. Therefore, the teachers' teaching students through IBL does not reach the last level of IBL in which students play roles as professional scientists or researchers.

Inquiry-based learning helps students develop their studies on Physics, behavior, attitude, teamwork, class participation, especially basic and integrated science process skills. Be informed that these students' developments and improvements depend on their degree of understanding and existing knowledge. It means that the inquiry-based learning approach cannot make low-ability students immediately become outstanding students. It requires enough amount of time with practice as much as possible to be familiar. In contrast, students who already have the ability to receive new knowledge learn fast through IBL. They quickly understand what their teachers provide and intend students to do things. IBL impartially draw low-ability students' attraction to Physics subject only. Regarding the degree of in-depth understanding, later on, it depends on the students themselves whether they try hard to study or not with fostering, motivation, and encouragement from teachers and parents.

IBL also benefits not only students but also the teachers themselves. This teaching approach enables teachers to be well-prepared before teaching students. For example, teachers must prepare in advance for teaching materials, experiment tools, worksheets, etc., which can be done by researching and making plans. These actions enable the teachers to gradually change their teaching habits from teaching with only textbooks or lesson plans to more creation and innovation, which can attract students to more participate in-class activities. Moreover, according to this study, the teachers have developments and improvements of ability on research skills, computer skills, and ICT skills. Learning through inquiry truly makes both teachers and students become active researchers regardless of ways to find answers and results, whether they respond to the inquiry questions or not.

Even though IBL is an effective approach in teaching that helps students construct knowledge by themselves, it is not easy for teachers to achieve their objectives through this approach. Teachers have to spend much time researching, finding teaching materials, experiment tools, etc. Moreover, some experiment tools are too expensive and hard to find. Some experiments indeed exist in theories only. In reality, they might show different results because of various reasons, like shortages of standardized experiment labs and exact experiment materials. Importantly, some experiments can cause dangers to teachers and students who are conducting them when they do not know how to prevent accidents in the laboratory. When talking about students, common major concerns are teamwork and participation. Some students are not familiar with working in teams. This issue can lead to conflicts among members and having free-riders in the groups. Moreover, some students neglect the role of experimental equipment in IBL. They take the equipment as their enjoyment, which is opposite from the objectives of experiment topics or teachers' expectations. Therefore, teachers should have a high ability to manage students and guide them so that teaching and learning through the IBL approach are successful.

Overall, the current study shows that all teachers express the values of inquiry-based learning, which an approach is making high contribution to students for constructing knowledge, especially for exploring Physics phenomena. The students become active in their in-depth studies, understanding the correlation between variables in Physics formulations or phenomena. The students increase their creativity, projects, or solutions to any social issue that students notice in their real lives. Talking about students, they gain soft skills like communication, leadership, responsibilities, collaboration, and making decisions. These skills are beneficial for students and make them receive knowledge, skills, and attitude that are expectations in Cambodia's vision of a student for 2030. The students themselves also agree that IBL helps them improve their studies in Physics, discussion, and exchange ideas. The students are satisfied with their discoveries by themselves. Regarding this statement, to achieve these expectations, students should understand their group members' varying knowledge and skill levels. Working with members who are easy to talk to and collaborate with for one direction will help students feel unisolated and eager to do inquiry best from the heart with pleasure.

6.2 Limitations of the study

Along with the results obtained, a few limitations of this work should be noted. This study was conducted in a school only in Phnom Penh City, and the researcher could not conduct this study at another school in Battambang Province due to Covid-19. Therefore, the research results at a school could not be generalization to all schools.

Moreover, due to the small sample size, the researcher could only make inferences about this sample to a population of students and teachers who were in the upper-secondary level in the selected schools. However, it could not assume to apply toward the entire population of all students or to Cambodian students and teachers nationwide.

As all schools in Phnom Penh were closed due to the outbreak of Covid-19 pandemic, the researcher could not conduct the classroom observation method as the researcher had planned at the beginning of data collection procedure. Therefore, the researcher could not see whether the responses from the participants were consistent with their activities.

As the study employed only qualitative research design, quantitative study was still needed for in-depth information. The researcher did not implement IBL approach by himself on student participants. That stills makes the researcher doubtful whether the students' answers are consistent with experiment results or not.

6.3 Recommendation

The purpose of this study tends to seek the characteristics of IBL that lead to the existence of activity correlation between teachers and students in the Cambodian context. Based on the study findings, the researcher checked the results, discussed with the literature review, and reviewed all suggestions raised by the participants. These actions are the foundation for releasing a recommendation regarding IBL implications. All stakeholders should consider putting them into practice, and other significant limitations that hinder the researcher from continuing the current study further. The researcher also leaves considerable messages for other researchers or next generations to continue solving those issues.

Teachers

Inquiry-based learning can be used for all kinds of lessons. It does not adhere to experimental or non-experimental topics. It depends on the flexibility and creativity of teachers in organizing students' activities lesson procedures to get into the pattern of IBL theory and its levels. To increase confidence, teachers should try using the IBL approach as much as possible and following the characteristics of IBL correctly. It enables both teachers and students to try their best to explore solutions as responses to their problems. This activity also increases their research habits.

Moreover, teachers should join Professional Learning Communities to plan claim-evidence-reasoning activities and formative assessment. They can discuss their problems and share experiences related to their teaching profession to help improve the teaching ability of teachers. Importantly, teachers should have the ability to check their students' performances, know student's characteristics, varying background levels to support all levels, and study results among mixed-ability students in the class. This competency can help teachers minimize the standard deviation of students' studies by identifying problems or conditions that prevent inconsistency of outcomes among students in the class. Then teachers can use scaffolding activities with a "low floor" and "high ceiling" to deal with those issues.

Students

Inquiry-based learning works best when students enjoy learning in groups. In this case, the students should know their members' characteristics and try understanding their varying background levels of knowledge and living status or conditions. Moreover, each member should be patient and do not discriminate or interrupt ideas roughly whenever discussing. Instead, they should cooperate and exchange ideas reasonably and friendly to find the answer to proposed inquiry questions.

Outstanding students should learn to understand their friends who have lower knowledge levels or slow learners, waiting and explaining lessons or tasks to them when they are not clear. High-ability students can also motivate and encourage their friends or members to join the groups. When they feel that they are part of the group's responsibility, they will participate with satisfaction.

Regarding students with poor performance, they should try to listen to team leaders, learning their experience, especially do not hesitate to ask questions. They should remember that no one is perfect. If their ideas or actions are not successful or applicable to the inquiry, they should not feel depressed or frustrated. Failures are the way to success.

School principals

School principals also take a significant part in promoting inquiry-based learning in schools. This action can be seen by motivating teachers to use IBL as much as possible. Teachers feel motivated and encouraged when they receive praise or rewards from the school principals. Moreover, having enough teaching materials, experiment tools, and the internet really support the possibility of IBL practice at schools. The School principals should provide time for professional development in the PLC and time for planning. They should also care about that by having enough budget for supporting teaching IBL and finding more aids from various stakeholders like local non-organizations or international organizations to help teachers with knowledge and materials. In particular, the IBL procedure needs appropriate time to complete; therefore, it should have well-organized schedules for teachers to teach IBL classrooms.

The principal should also provide professional development opportunities for teachers to learn science content through the perspectives and methods of inquiry, and in the Table Standards for Professional Development Related to Inquiry (Council, 1996).

Table 14 Standards for professional development related to inquiry

Standards for professional development related to inquiry
Science learning experiences for teachers must: • involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding. • introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge. • incorporate ongoing reflection on the process and outcomes of understanding science through inquiry. • connect and integrate all pertinent aspects of science and science education. • use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.

Stakeholders or NGOs

Besides the above-mentioned relevant sectors, IBL needs support from Non-government organizations (NGOs). The supports may be provided in various aspects, like offering necessary teaching materials for IBL classrooms. Training teachers about IBL and other teaching methods is compulsory before they start teaching exact classes. NGOs cooperate with schools and provide vocational training to teachers or invite them to joins workshops related to teaching methodologies, especially inquiry-based learning. All these actions can ensure the sustainability of IBL implementation in schools.

Researchers

This study was conducted during the outbreak of Covid-19; therefore, the researcher could not take a real-class observation. In this meaning, the researcher recommends next-generation researchers who wish to conduct similar topics trying to take real-class observation to get more specific information from it.

Moreover, quantitative research should be added to this study. It means that the researcher would recommend other researchers trying to conduct some experiments if they have similar topic research. The researchers should teach students by themselves using the IBL approach and then assign tests for them. Thus, the results obtained will be more specific and reliable.

Last but not least, if possible, further study should be more extensive by conducting similar research in more than one school. The researchers compare results received among those schools and check whether different contexts have significant impacts on IBL implementation or not.

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APPENDIX A

SEMI-STRUCTURED INTERVIEW PROTOCOL FOR TEACHERS

New Generation Pedagogical Research Center

Master of Education in Mentoring

My name is Mel Sereynivorth, a student of Cohort 2 of Master of Education in Mentoring, New Generation Pedagogical Research Center. The main purpose of this semi-structured interview is to explore Teachers' Perceptions of Inquiry-Based Learning Applied in Physics at Upper-secondary Level. All of participants are selected to join in this study and they have right to stop or reject to join at any time, before or within the interview. They will be safe whatever they answer (no threaten, fail their examination, or lose any marks and so on). All of the data will be anonymous and kept in confidential.

I. Demographic Data

1.1 Name: ______________________

1.2 Gender: _____________________

1.3 Age: ________________________

1.4 Marital Status: ________________

1.5 Highest level of education: _________________________________

1.6 Professional training: ______________________________________

1.7 Professional training institute: _______________________________

1.8 Subject major (s): _____________________________

1.9 Teaching experience of Physics: ________________ (year)

1.10 Teaching experience of Physics at XX High School: _____________ (year)

1.11 Teaching hour per week: ________________

1.12 Number of class: ________________

1.13 Grade (s): ________________

II. Teachers' understanding of IBL and implementing in Physics

2.1. Do you like teaching Physics? Why or why not?

2.2. Have you ever heard about IBL approach? If yes, where you get the information from?

2.3. In your opinion, what does IBL mean?

2.4. Have you ever heard about the levels of IBL? If so, what are they? At what level of IBL do you think you have used in the classrooms?

2.5. Could you please describe the process of IBL which you have implemented?

2.6. Could you please describe your roles and your students' roles in IBL procedure?

III. Positive outcomes in the process and after IBL implementation

3.1 In the process of using IBL, have you noticed any improvements from students (for example: participation, behavior, content knowledge, basic science process skills, advanced science process skills, etc.)?

3.2 In the process of using IBL, have you noticed any improvements of yourself (for example: student management, teaching techniques, student attraction, problem introduction, leadership, mastering on the scientific method, science process skills, inductive and deductive reasoning, etc.)?

3.3 After the process of using IBL, have you noticed any improvements from students (for example: behavior, teamwork, content knowledge, assessment, practice, research, etc.)?

3.4 After the process of using IBL, have you noticed any improvements of yourself (for example: content knowledge, research, science process skills, teaching methods, etc.)?

IV. Challenges of using IBL in classrooms

a. Before the process

4.1 Before the process of IBL, have you faced any issues (for example: lesson plan, creating inquiry questions, experiment tool preparation, etc.)?

4.2 How have you dealt with those issues? And is there anything changed?

b. In the process

4.3 In the process of IBL, have you faced any issues (for example: student activity preparation, classroom management, experiment plan and installation, time management, etc.)?

4.4 How have you dealt with those issues? And is there anything changed?

c. After the process

4.5 After the process of IBL, have you faced any issues (for example: student assessment and evaluation, testing design, cleaning experiment lab, safety, healthy, etc.)?

4.6 How have you dealt with those issues? And is there anything changed?

V. Teachers' perceptions of using IBL in Physics course

5.1 In your opinion, what do you think of inquiry-based learning? Please explain.

5.2 Do you think IBL is a suitable approach in teaching Physics for upper-secondary level? What type of lesson that should apply IBL? Please explain.

5.3 Would you recommend IBL to other teachers? Why or why not?

5.4 Do you have any comments or suggestion to improve your practice of implementing IBL?

Thank you for spending your time to participate in this interview.

APPENDIX B

SEMI-STRUCTURED INTERVIEW PROTOCOL FOR STUDENTS

New Generation Pedagogical Research Center

Master of Education in Mentoring

My name is Mel Sereynivorth, a student of Cohort 2 of Master of Education in Mentoring, New Generation Pedagogical Research Center. The main purpose of this semi-structured interview is to explore Students' Perceptions of Inquiry-Based Learning Applied in Physics at Upper-secondary Level. All of participants are selected to join in this study and they have right to stop or reject to join at any time, before or within the interview. They will be safe whatever they answer (no threaten, fail their examination, or lose any marks and so on). All of the data will be anonymous and kept in confidential.

I. **Demographic Data**

1.1 Name: ___________________________

1.2 Gender: __________________________

1.3 Age: _____________________________

1.4 Grade: ___________________________

1.5 Subjects learned at school:

____

1.6 Favorite subjects and reasons:

____

1.7 Non-favorite subjects and reasons:

____

II. **Students' understanding of IBL and implementation in Physics**

2.1 Do you like Physics? Why or why not?

2.2 Has your Physics teacher introduced any problems or phenomena and then provided questions, asking students to work in groups to find answers or do experiment and reported the result in the end?

2.3 Has your Physics teacher assigned students' roles clearly or students assigned their roles themselves? Do you remember your roles?

2.4 Could you describe activities that your teacher have done and students' activities in such an experiment learning? And your activities?

2.5 Has your teacher told you or facilitated you with: inquiry formulation and hypotheses, experiment plan and installation, result, analysis, conclusion, etc.?

III. Positive outcomes in IBL implementation

3.1 In the process of the above kind of learning, have you noticed any improvements (for example: content knowledge, friendship, confidence, observation, basic science process skills, advance science process skills, etc.)?

3.2 After the process, have you noticed any improvements (for example: more understanding, teamwork, test, practice, research, etc.)?

IV. Challenges of IBL

a. In the process

4.1 In the process of learning, have you faced any problems (for example: creating inquiry questions, using experiment tools, time management, teamwork, etc.)?

4.2 How have you solved those problems? And anything changed?

b. After the process

4.3 After the process, have you faced any problems (for example: testing, homework, safety, health, cleaning experiment lab, etc.)?

4.4 How have you solved those problems? And anything changed?

V. Students' perceptions of IBL in Physics course

5.1 In your opinion, what do you think of inquiry-based learning your teacher has used in Physics class?

5.2 Do you enjoy learning Physics through IBL? Why or why not? Please explain.

5.3 Do you have any comments or suggestion regarding IBL?

Thank you for spending your time to participate in this interview.

APPENDIX C

មគ្គុទេសន៍សំណួរសម្រាប់សម្ភាសគ្រូ

I. ព័ត៌មានទូទៅរបស់អ្នកចូលរួម

1.1 ឈ្មោះអ្នកចូលរួម៖...................................
1.2 ភេទ៖...
1.3 អាយុ៖...
1.4 ស្ថានភាពគ្រួសារ៖...................................
1.5 កម្រិតវប្បធម៌៖...
1.6 សញ្ញាបត្របណ្តុះបណ្តាលវិជ្ជាជីវៈ៖...
1.7 សាលាបណ្តុះបណ្តាល៖..
1.8 ឯកទេស៖...
1.9 បទពិសោធន៍បង្រៀនរូបវិទ្យា៖...................(សាលាចំណេះទូទៅ)
1.10 បទពិសោធន៍បង្រៀនរូបវិទ្យា៖...................(សាលាជំនាន់ថ្មីព្រះស៊ីសុវត្ថិ)
1.11 ម៉ោងបង្រៀន៖.....................ម៉ោង/សប្តាហ៍
1.12 ចំនួនថ្នាក់បង្រៀន៖.....................កម្រិតថ្នាក់..

II. ការយល់ដឹងរបស់គ្រូអំពី IBL និងដំណើរការIBL ក្នុងមុខវិជ្ជារូបវិទ្យា

2.1 តើអ្នកចូលចិត្តបង្រៀនមុខវិជ្ជារូបវិទ្យាដែរឬទេ? ហេតុអ្វី?
2.2 តើអ្នកធ្លាប់បានលឺពីវិធីសាស្រ្តរៀនតាមបែបរិះរកដែរឬទេ? បើធ្លាប់ តើលឺនៅកន្លែងណាខ្លះ?
2.3 តាមគំនិតរបស់អ្នក តើការរៀនតាមបែបរិះរកមានន័យដូចម្តេច?
2.4 តើអ្នកធ្លាប់បានដឹងពីកម្រិតនៃការរៀនតាមបែបរិះរកដែរឬទេ? បើធ្លាប់ តើមានប៉ុន្មានកម្រិត? អ្វីខ្លះ? តើអ្នកអាចពន្យល់ត្រួសៗពីកម្រិតនីមួយៗបានដែរឬទេ? តើកម្រិតណាខ្លះដែលអ្នកគិតថាអ្នកបានអនុវត្តនៅក្នុងថ្នាក់រៀនរបស់អ្នក?
2.5 តើអ្នកអាចរៀបរាប់ពីដំណើរការបង្រៀនតាមវិធីសាស្រ្តបែបរិះរក ដែលអ្នកធ្លាប់បានអនុវត្តកន្លងមកដែរឬទេ?
2.6 តើអ្នកអាចរៀបរាប់ពីតួនាទីរបស់អ្នក ក៏ដូចជាតួនាទីរបស់សិស្សរបស់អ្នកក្នុងដំណើរការរៀនតាមវិធីសាស្រ្តបែបរិះរក ដែលអ្នកធ្លាប់បានអនុវត្តកន្លងមកដែរឬទេ?

III. លទ្ធផលជាវិជ្ជមាន ក្នុងកំឡុងពេល និងក្រោយដំណើរការបង្រៀនតាមបែបIBL

3.1 ក្នុងកំឡុងពេលដំណើរការ តើអ្នកបានកត់សំគាល់ឃើញសិស្សរបស់អ្នកមានភាពរីកចម្រើនដែរឬទេ(ឧទាហរណ៍ ការចូលរួម អាកប្បកិរិយា ការចាប់អារម្មណ៍ខ្លឹមសារមេរៀនរូបវិទ្យា

បំណិនវិទ្យាសាស្ត្រកម្រិតទាប(សង្កេត ការធ្វើចំណែកថ្នាក់ ការសន្និដ្ឋាន វង្វាស់វង្វាល់/ការវាស់វែង ការទស្សន៍ទាយ ការផ្តល់ព័ត៌មាន...) បំណិនវិទ្យាសាស្ត្រកម្រិតខ្ពស់(ការកំណត់រក និងការត្រួតពិនិត្យអថេរ ការបង្កើតសម្មតិកម្ម ការកំណត់និយមន័យ ការសង់ក្រាប និងបកស្រាយទិន្នន័យ ការធ្វើពិសោធន៍ អនុមានរួម និងអនុមានញែក...))? បើមានសូមរៀបរាប់។

3.2 ក្នុងកំឡុងពេលដំណើរការ តើអ្នកបានកត់សំគាល់ឃើញខ្លួនអ្នកផ្ទាល់មានភាពរីកចម្រើនដែរឬទេ(ឧទារហាណ៍ ការគ្រប់គ្រងសិស្ស ការទាក់ទាញចំណាប់អារម្មណ៍សិស្ស បច្ចេកទេសក្នុងការនាំយកបញ្ហាធ្វើឱ្យសិស្សបង្កើតចម្ងល់ ការដឹកនាំសិស្សពិសោធន៍ ច្បាស់លាស់ពីវិធីវិទ្យាសាស្ត្រ បំណិនវិទ្យាសាស្ត្រ វិធីអនុមានរួម និងអនុមានញែក សន្លឹកកិច្ចការ ...)? បើមានសូមរៀបរាប់។

3.3 ក្រោយពេលដំណើរការ តើអ្នកបានកត់សំគាល់សិស្សរបស់អ្នកមានភាពរីកចម្រើនដែរឬទេ (ឧទារហាណ៍ អាកប្បកិរិយា ការធ្វើការជាក្រុម ការយល់ដឹងពីខ្លឹមសារមេរៀនរូបវិទ្យា ការវាយតម្លៃ ការអនុវត្ត ការសិក្សាស្រាវជ្រាវបន្ថែម បំណិនវិទ្យាសាស្ត្រកម្រិតទាប បំណិនវិទ្យាសាស្ត្រកម្រិតខ្ពស់...)? បើមានសូមរៀបរាប់។

3.4 ក្រោយពេលដំណើរការ តើអ្នកបានកត់សំគាល់ខ្លួនអ្នកផ្ទាល់មានភាពរីកចម្រើនដែរឬទេ (ឧទារហាណ៍ ការលើកទឹកចិត្តពីគណៈគ្រប់គ្រង/មាតាបិតាសិស្ស ភាពច្បាស់លើខ្លឹមសារមេរៀនរូបវិទ្យា ការសិក្សាស្រាវជ្រាវបន្ថែម ការប្រើប្រាស់វិធីវិទ្យាសាស្ត្រ បំណិនវិទ្យាសាស្ត្រ វិធីអនុមានរួម និងអនុមានញែក មានប្រជាប្រិយភាព...)? បើមានសូមរៀបរាប់។

IV. ឧបសគ្គ និងបញ្ហាប្រឈមនៃវិធីសាស្ត្ររៀនតាមបែបរិះរក

មុនដំណើរការ

4.1 មុនដំណើរការបង្រៀន តើអ្នកបានជួបឧបសគ្គ និងបញ្ហាប្រឈមអ្វីខ្លះ (ឧទាហរណ៍ ការរៀបចំកិច្ចតែងការ ការបង្កើតសំណួរគន្លឹះ ការរៀបចំសម្ភារពិសោធន៍ ...)? បើមាន ចូររៀបរាប់ និងប្រាប់មូលហេតុ។

4.2 តើអ្នកបានដោះស្រាយបញ្ហាទាំងអស់នោះយ៉ាងដូចម្តេច? តើមានការប្រែប្រួលដែរឬទេក្រោយដោះស្រាយរួច?

កំឡុងពេលដំណើរការ

4.3 ក្នុងកំឡុងពេលដំណើរការបង្រៀន តើអ្នកបានជួបឧបសគ្គ និងបញ្ហាប្រឈមអ្វីខ្លះ (ឧទាហរណ៍ ការរៀបចំសកម្មភាពសិស្ស ការគ្រប់គ្រងថ្នាក់រៀន ប្លង់ពិសោធន៍ ការតម្លើងសម្ភារពិសោធន៍ ការគ្រប់គ្រងពេលវេលា ការឆ្លើយសំណួរដែលគ្រូមិនទាន់ដឹងចម្លើយ...)? បើមាន ចូររៀបរាប់ និងប្រាប់មូលហេតុ។

តើអ្នកបានដោះស្រាយបញ្ហាទាំងអស់នោះយ៉ាងដូចម្តេច? តើមានការប្រែប្រួលដែរឬទេក្រោយដោះស្រាយរួច?

ក្រោយពេលដំណើរការ

4.4 ក្រោយដំណើរការបង្រៀន(ការវាយតម្លៃចំណេះដឹងសិស្ស) តើអ្នកបានជួបឧបសគ្គ និងបញ្ហាប្រឈមអ្វីខ្លះ (ឧទាហរណ៍ ការរៀបចំតេស្ត ការវាស់ស្ទង់ការយល់ដឹងរបស់សិស្ស ការរៀបចំបន្ទប់ពិសោធន៍ បញ្ហាសុខភាព សុវត្ថិភាព...)? បើមាន ចូររៀបរាប់ និងប្រាប់មូលហេតុ។

4.5 តើអ្នកបានដោះស្រាយបញ្ហាទាំងអស់នោះយ៉ាងដូចម្តេច? តើមានការប្រែប្រួលដែរឬទេក្រោយដោះស្រាយរួច?

V. ការយល់ឃើញរបស់គ្រូអំពីការបង្រៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យា

5.1 ជាការយល់ឃើញផ្ទាល់ តើអ្នកយល់យ៉ាងណាដែរចំពោះវិធីសាស្ត្របង្រៀនតាមបែបរិះរក (ល្អ/ មិនដឹង/ មិនល្អ)? ហេតុអ្វី? ចូរបកស្រាយ។

5.2 តើអ្នកគិតថាវិធីសាស្ត្របង្រៀនតាមបែបរិះរក សាកសមប្រើក្នុងការបង្រៀនមុខវិជ្ជារូបវិទ្យានៅកម្រិតទុតិយភូមិដែរឬទេ? បើសាកសម ក្នុងមេរៀនប្រភេទណាដែរ? ហេតុអ្វី? ចូរពន្យល់។

5.3 តើអ្នកមានបំណងណែនាំវិធីសាស្ត្រមួយនេះ ទៅកាន់គ្រូដទៃទៀតដែរឬទេ? បើមាន ហេតុអ្វី? បើមិនមាន ហេតុអ្វី?

5.4 តើអ្នកមានជាមតិយោបល់ ឬសំណូមពរអ្វីដែរឬទេ ទាក់ទងនឹងការអនុវត្តរបស់អ្នកចំពោះវិធីសាស្ត្របង្រៀនតាមបែបរិះរក? ឬ ភាពពាក់ព័ន្ធផ្សេងៗទៅនឹងវិធីសាស្ត្របង្រៀនតាមបែបរិះរក?

សូមអរគុណដែលបានចំណាយពេលវេលាដ៏មានតម្លៃរបស់អ្នកសម្រាប់ធ្វើបទសម្ភាសន៍មួយនេះ!

APPENDIX D

មគ្គុទេសន៍សំណួរសម្រាប់សម្ភាសសិស្ស

I. ព័ត៌មានទូទៅរបស់អ្នកចូលរួម

1.13 ឈ្មោះអ្នកចូលរួម៖...

1.14 ភេទ៖...

1.15 អាយុ៖..

1.16 រៀនថ្នាក់ទី៖...

1.17 មុខវិជ្ជារៀននៅសាលា៖..

1.18 មុខវិជ្ជាដែលចូលចិត្តរៀនជាងគេ និងមូលហេតុ៖

....

1.19 មុខវិជ្ជាដែលមិនសូវចូលចិត្តរៀនជាងគេ និងមូលហេតុ៖

....

II. ការយល់ដឹងរបស់សិស្សអំពី IBL និងដំណើរការIBL ក្នុងមុខវិជ្ជារូបវិទ្យា

2.7 តើអ្នកចូលចិត្តរៀនមុខវិជ្ជារូបវិទ្យាដែរឬទេ?

☐ ចូលចិត្ត មូលហេតុ៖...

☐ មិនចូលចិត្ត មូលហេតុ៖...

2.8 តើគ្រូរូបវិទ្យារបស់អ្នកធ្លាប់បានលើកយកបាតុភូតរូបណាមួយមកបង្ហាញក្នុងថ្នាក់ រួចដាក់សំណួររួមមួយ បន្ទាប់មកចែកសិស្សជាក្រុមរិះរកចម្លើយឬធ្វើពិសោធន៍ រួចជាចុងក្រោយឱ្យដំណាងក្រុមរាយការណ៍ពីចម្លើយដែរឬទេ?

☐ ធ្លាប់ ☐ មិនធ្លាប់ ☐ មិនដឹង

2.9 តើគ្រូរូបវិទ្យារបស់អ្នកធ្លាប់បានបង្រៀនដោយប្រើវិធីសាស្ត្របែបហ្នឹងជាញឹកញាប់ដែរឬទេ?

☐ ជាញឹកញាប់ ☐ មិនញឹកញាប់ ☐ មិនដឹង

2.10 តើគ្រូរូបវិទ្យាបានបែកចែកតួនាទីរបស់សិស្សនីមួយៗ បានច្បាស់លាស់ដែរឬទេ ពេលចែកសិស្សធ្វើការជាក្រុមម្តងៗ? ឬក៏សិស្សក្នុងក្រុមបែងចែកដោយខ្លួនឯង? តើតួនាទីរបស់អ្នកជាអ្វី (ឧទាហរណ៍ ប្រធានក្រុម សមាជិក អ្នកកត់ត្រា...)?

2.11 ប្រសិនបើវិធីសាស្ត្រមួយនេះគ្រូរូបវិទ្យារបស់អ្នកធ្លាប់បានប្រើពីមុនមក តើគាត់ឱ្យអ្នកធ្វើសកម្មភាពអ្វីខ្លះពេលដែលអ្នករៀនតាមវិធីសាស្ត្រមួយនេះ? ចូររៀបរាប់។

2.12 តើគ្រូបរិទ្យារបស់អ្នកបានប្រាប់អ្នកទាំងស្រុង ឬគ្រាន់តែពន្យល់តិចតួចរួចឱ្យអ្នកធ្វើដោយខ្លួនឯងចំពោះ៖ ការបង្កើតចម្ងល់(សំណួរគន្លឹះ) ការទស្សន៍ទាយទុកជាមុន ការរៀបចំដំណើរការរិះរកឬពិសោធន៍ ការបង្ហាញលទ្ធផល ការសន្និដ្ឋាន... ?

III. លទ្ធផលជាវិជ្ជមាន ក្នុងកំឡុងពេល និងក្រោយដំណើរការបង្រៀនតាមបែបIBL

3.5 ក្នុងកំឡុងពេលដំណើរការរៀនតាមវិធីសាស្ត្រនេះ តើអ្នកបានកត់សំគាល់ខ្លួនអ្នកមានភាពរីកចម្រើនដែរឬទេ? (ឧទាហរណ៍ យល់ដឹងពីខ្លឹមសារមេរៀនរូបវិទ្យា ភាពស្និទ្ធស្នាលជាមួយមិត្តរួមថ្នាក់ ការទំនុកចិត្តលើខ្លួនឯង ការសង្កេតបាតុភូត បំណិនវិទ្យាសាស្ត្រកម្រិតទាប (សង្កេត ការធ្វើចំណែកថ្នាក់ ការសន្និដ្ឋាន វង្វាស់វង្វាល់/ការវាស់វែង ការទស្សន៍ទាយ ការផ្តល់ព័ត៌មាន...) បំណិនវិទ្យាសាស្ត្រកម្រិតខ្ពស់(ការកំណត់រក និងការត្រួតពិនិត្យអថេរ ការបង្កើតសម្មតិកម្ម ការកំណត់និយមន័យ ការសង់ក្រាប និងបកស្រាយទិន្នន័យ ការធ្វើពិសោធន៍ អនុមានរួម និងអនុមានញែក...))? បើមានសូមរៀបរាប់។

3.6 ក្រោយពេលដំណើរការ តើអ្នកបានកត់សំគាល់ខ្លួនអ្នកផ្ទាល់មានភាពរីកចម្រើនដែរឬទេ (ឧទារហណ៍ អាកប្បកិរិយា ការយល់ដឹងពីខ្លឹមសារមេរៀនរូបវិទ្យា ការធ្វើការងារក្រុម ការប្រឡង ការអនុវត្ត ការសិក្សាស្រាវជ្រាវបន្ថែម បំណិនវិទ្យាសាស្ត្រកម្រិតទាប បំណិនវិទ្យាសាស្ត្រកម្រិតខ្ពស់...)? បើមានសូមរៀបរាប់។

IV. ឧបសគ្គ និងបញ្ហាប្រឈមនៃវិធីសាស្ត្ររៀនតាមបែបរិះរក

កំឡុងពេលដំណើរការ

4.6 ក្នុងកំឡុងពេលដំណើរការរៀន តើអ្នកបានជួបឧបសគ្គ និងបញ្ហាប្រឈមអ្វីខ្លះ (ឧទាហរណ៍ ការបង្កើតសំណួរគន្លឹះ ការប្រើប្រាស់សម្ភារពិសោធន៍ ការគ្រប់គ្រងពេលវេលា ការធ្វើការជាក្រុម...)? បើមាន ចូររៀបរាប់ និងប្រាប់មូលហេតុ។

4.7 តើអ្នកបានដោះស្រាយបញ្ហាទាំងអស់នោះយ៉ាងដូចម្តេច? តើគ្រូរបស់អ្នកដោះស្រាយបញ្ហាទាំងនោះដូចម្តេចខ្លះ? តើមានការប្រែប្រួលដែរឬទេក្រោយដោះស្រាយរួច?

ក្រោយពេលដំណើរការ

4.8 ក្រោយដំណើរការរៀន តើអ្នកបានជួបឧបសគ្គ និងបញ្ហាប្រឈមអ្វីខ្លះ (ឧទាហរណ៍ ការប្រឡង កិច្ចការផ្ទះសុខភាព សុវត្ថិភាព ការសម្អាតបន្ទប់ពិសោធន៍...)? បើមាន ចូររៀបរាប់ និងប្រាប់មូលហេតុ។

4.9 តើអ្នកបានដោះស្រាយបញ្ហាទាំងអស់នោះយ៉ាងដូចម្តេច? តើគ្រូរបស់អ្នកដោះស្រាយបញ្ហាទាំងនោះដូចម្តេចខ្លះ? តើមានការប្រែប្រួលដែរឬទេក្រោយដោះស្រាយរួច?

V. ការយល់ឃើញរបស់សិស្សអំពីការបង្រៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យា

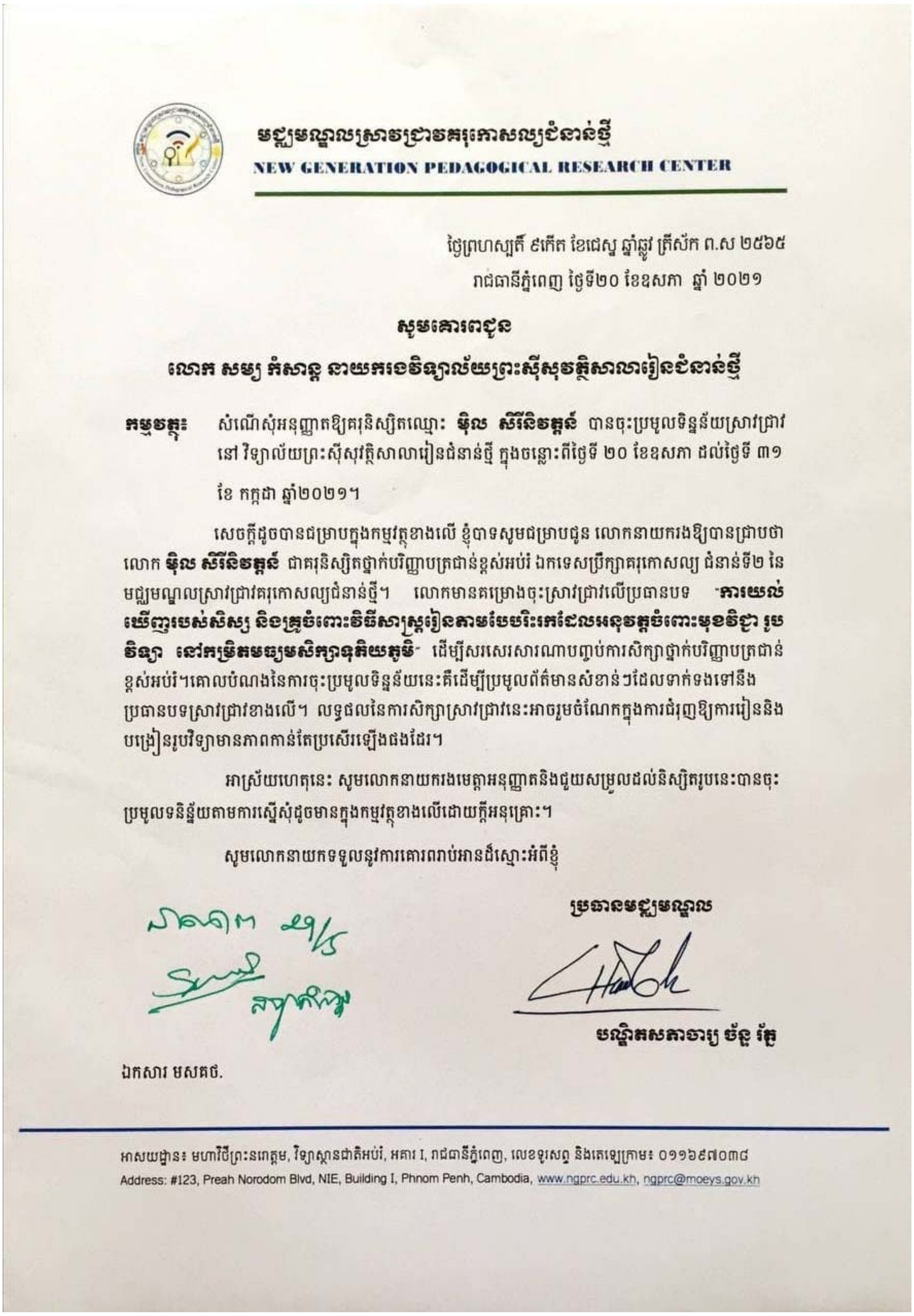
5.1 ជាការយល់ឃើញផ្ទាល់ តើអ្នកយល់យ៉ាងណាដែរបើគ្រូរូបវិទ្យាឱ្យអ្នករៀនតាមវិធីសាស្ត្រដូចដែលបានពិភាក្សាខាងលើ (ល្អ/ មិនដឹង/ មិនល្អ)? ហេតុអ្វី? ចូរបកស្រាយ។

5.2 តើការរៀនតាមវិធីសាស្ត្របង្រៀនបែបនេះ ធ្វើឱ្យអ្នកចូលចិត្តរៀនមុខវិជ្ជារូបវិទ្យាដែរឬទេ? ហេតុអ្វី? ចូរពន្យល់។

5.3 តើអ្នកមានជាមតិយោបល់ ឬសំណូមពរអ្វីដែរឬទេ ទាក់ទងនឹងការរៀនរបស់អ្នកតាមវិធីសាស្ត្របង្រៀនតាមបែបរិះរក?

សូមអរគុណដែលបានចំណាយពេលវេលាដ៏មានតម្លៃរបស់អ្នកសម្រាប់ធ្វើបទសម្ភាសន៍មួយនេះ!

APPENDIX E



មជ្ឈមណ្ឌលស្រាវជ្រាវគរុកោសល្យជំនាន់ថ្មី

NEW GENERATION PEDAGOGICAL RESEARCH CENTER

ថ្ងៃព្រហស្បតិ៍ ៩កើត ខែជេស្ឋ ឆ្នាំឆ្លូវ ត្រីស័ក ព.ស ២៥៦៥

រាជធានីភ្នំពេញ ថ្ងៃទី២០ ខែឧសភា ឆ្នាំ ២០២១

សូមគោរពជូន

លោក សម្ប កំសាន្ត នាយករងវិទ្យាល័យព្រះស៊ីសុវត្ថិសាលារៀនជំនាន់ថ្មី

កម្មវត្ថុ៖ សំណើសុំអនុញ្ញាតឱ្យគរុនិស្សិតឈ្មោះ **មិុល សិរីនិមត្តន៍** បានចុះប្រមូលទិន្នន័យស្រាវជ្រាវ នៅ វិទ្យាល័យព្រះស៊ីសុវត្ថិសាលារៀនជំនាន់ថ្មី ក្នុងចន្លោះពីថ្ងៃទី ២០ ខែឧសភា ដល់ថ្ងៃទី ៣១ ខែ កក្កដា ឆ្នាំ២០២១។

សេចក្តីដូចបានជម្រាបក្នុងកម្មវត្ថុខាងលើ ខ្ញុំបាទសូមជម្រាបជូន លោកនាយករងឱ្យបានជ្រាបថា លោក **មិុល សិរីនិមត្តន៍** ជាគរុនិស្សិតថ្នាក់បរិញ្ញាបត្រជាន់ខ្ពស់អប់រំ ឯកទេសប្រឹក្សាគរុកោសល្យ ជំនាន់ទី២ នៃ មជ្ឈមណ្ឌលស្រាវជ្រាវគរុកោសល្យជំនាន់ថ្មី។ លោកមានគម្រោងចុះស្រាវជ្រាវលើប្រធានបទ "**ការយល់ឃើញរបស់សិស្ស និងគ្រូចំពោះវិធីសាស្ត្ររៀនតាមបែបរិះរកដែលអនុវត្តចំពោះមុខវិជ្ជា រូបវិទ្យា នៅកម្រិតមធ្យមសិក្សាទុតិយភូមិ**" ដើម្បីសរសេរសារណាបញ្ចប់ការសិក្សាថ្នាក់បរិញ្ញាបត្រជាន់ខ្ពស់អប់រំ។គោលបំណងនៃការចុះប្រមូលទិន្នន័យនេះគឺដើម្បីប្រមូលព័ត៌មានសំខាន់ៗដែលទាក់ទងទៅនឹង ប្រធានបទស្រាវជ្រាវខាងលើ។ លទ្ធផលនៃការសិក្សាស្រាវជ្រាវនេះអាចរួមចំណែកក្នុងការជំរុញឱ្យការរៀននិង បង្រៀនរូបវិទ្យាមានភាពកាន់តែប្រសើរឡើងផងដែរ។

អាស្រ័យហេតុនេះ សូមលោកនាយករងមេត្តាអនុញ្ញាតនិងជួយសម្រួលដល់និស្សិតរូបនេះបានចុះ ប្រមូលទនិន្នន័យតាមការស្នើសុំដូចមានក្នុងកម្មវត្ថុខាងលើដោយក្តីអនុគ្រោះ។

សូមលោកនាយកទទួលនូវការគោរពរាប់អានដ៏ស្មោះអំពីខ្ញុំ

ប្រធានមជ្ឈមណ្ឌល

បណ្ឌិតសភាចារ្យ ច័ន្ទ រ័ត្ន

ឯកសារ មសគថ.

អាសយដ្ឋាន៖ មហាវិថីព្រះនរោត្តម, វិទ្យាស្ថានជាតិអប់រំ, អគារ I, រាជធានីភ្នំពេញ, លេខទូរសព្ទ និងតេឡេក្រាម៖ ០១១៦៩៧០៣៨

Address: #123, Preah Norodom Blvd, NIE, Building I, Phnom Penh, Cambodia, www.ngprc.edu.kh, ngprc@moeys.gov.kh

APPENDIX F

ឧបសម្ព័ន្ធ ខ៖ សំណើសុំធ្វើការសម្ភាសន៍ (សម្រាប់គ្រូ)

ខ្ញុំបាទឈ្មោះ **មុិល សិរីនិវត្តន៍** ដែលជានិស្សិតកំពុងសិក្សាបរិញ្ញាបត្រជាន់ខ្ពស់ឯកទេសប្រឹក្សាគរុកោសល្យ នៅមជ្ឈមណ្ឌលស្រាវជ្រាវគរុកោសល្យជំនាន់ថ្មីនៃវិទ្យាស្ថានជាតិអប់រំ។ ខ្ញុំបាទបាន និងកំពុងធ្វើការសិក្សាស្រាវជ្រាវលើប្រធានបទ "**ការយល់ឃើញរបស់សិស្ស និងគ្រូចំពោះវិធីសាស្ត្ររៀនតាមបែបរិះរកដែលអនុវត្តចំពោះមុខវិជ្ជារូបវិទ្យានៅកម្រិតមធ្យមសិក្សាទុតិយភូមិ**" ដែលវាជាសារណាបញ្ចប់ថ្នាក់អនុបណ្ឌិតរបស់ខ្ញុំ។

១. គោលបំណងនៃការស្រាវជ្រាវ

ការសិក្សានេះមានគោលបំណងផ្តល់ជូននូវចរិកលក្ខណៈនៃការរៀនតាមបែបរិះរកដែលបម្រើឱ្យការអប់រំវិទ្យាសាស្ត្រជាមួយនឹងការផ្សារភ្ជាប់តួនាទីក្នុងការរិះរករវាងគ្រូ និងសិស្ស។ លទ្ធផលនៃការស្រាវជ្រាវនេះ នឹងបង្ហាញជូននូវព័ត៌មានចាំបាច់ដែលពាក់ព័ន្ធនឹងមធ្យោបាយនៃការដាក់ឱ្យដំណើរការវិធីសាស្ត្ររៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យាក្នុងបរិបទប្រទេសកម្ពុជា។ ជាពិសេសជាងនេះទៅទៀត ការសិក្សាស្រាវជ្រាវនេះនឹងចង្អុលបង្ហាញពីការយល់ឃើញពិតប្រាកដរបស់គ្រូនិងសិស្សចំពោះវិធីសាស្ត្ររៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យារួមមាន លទ្ធផលជាផ្លែផ្កាក្នុងការសិក្សារបស់សិស្ស ក៏ដូចជាឧបសគ្គផ្សេងៗដែលរាំងស្ទះដំណើរការរៀនតាមវិធីសាស្ត្រមួយនេះ។ ការសិក្សាមួយនេះ នឹងជាផ្នែកមួយដែលរួមចំណែកក្នុងការលើកកម្ពស់ការបង្រៀន និងរៀនមុខវិជ្ជារូបវិទ្យាឱ្យកាន់តែប្រសើរ សម្រាប់ការអប់រំនៅប្រទេសកម្ពុជា។ លើសពីនេះ ការសិក្សានេះអាចនឹងក្លាយទៅជាឯកសារយោងសម្រាប់ការស្រាវជ្រាវបន្ថែមទៀតលើប្រធានបទស្រដៀងគ្នា ដែលនឹងផ្តល់អត្ថប្រយោជន៍ជាច្រើនដល់សិស្ស/និស្សិត គ្រូបង្រៀន ក៏ដូចជាស្ថាប័នពាក់ព័ន្ធ។

២. ដំណើរការនៃការស្រាវជ្រាវ

ប្រសិនបើលោកគ្រូ/អ្នកគ្រូចូលរួមក្នុងការសម្ភាសន៍ នោះលោកគ្រូ អ្នកគ្រូនឹងត្រូវសួរនូវសំណួរមួយចំនួនទាក់ទងនឹងប្រធានបទស្រាវជ្រាវ។ ក្នុងសំណួរនីមួយៗអាចចំណាយពេលពី ៣ ទៅ ៥នាទី ដូចនេះការសម្ភាសន៍ អាចចំណាយពេលប្រហែល ៣០ ទៅ ៤០នាទី ហើយអំឡុងពេលសម្ភាសន៍ ខ្ញុំនឹងថតសម្លេងដើម្បីជាភាពងាយស្រួល។ ចំពោះឈ្មោះរបស់លោកគ្រូ/អ្នកគ្រូនឹងមិនត្រូវបានបង្ហាញក្នុងការស្រាវជ្រាវទេបើគ្មានការអនុញ្ញាតពី លោកគ្រូ/អ្នកគ្រូ ហើយការថតសម្លេងនេះគ្រាន់ជាជំនួយសម្រាប់ខ្ញុំក្នុងការបកស្រាយទិន្នន័យតែប៉ុណ្ណោះ។

៣. គោលការណ៍រក្សាការសម្ងាត់

ព័ត៌មានទាំងអស់នឹងរក្សាការសម្ងាត់ ដោយមានតែអ្នកស្រាវជ្រាវតែម្នាក់ដែលអាចប្រើប្រាស់បាន។ វាមិនមែនជាតេស្ត ហើយក៏គ្មានចម្លើយខុសឬត្រូវដែរ។ ព័ត៌មានរបស់លោកគ្រូ/អ្នកគ្រូ ពិតជាមានសារៈសំខាន់ណាស់សម្រាប់ខ្ញុំ ហើយខ្ញុំសង្ឃឹមថាលោកគ្រូ/អ្នកគ្រូ អាចចូលរួមជាមួយការសិក្សាស្រាវជ្រាវនេះ។ វាជាជម្រើសរបស់លោកគ្រូ អ្នកគ្រូ បើទោះបីជាលោកគ្រូ/អ្នកគ្រូ ចង់ឬមិនចង់ចូលរួមក៏ដោយ។ ប្រសិនបើលោកគ្រូ/អ្នកគ្រូ ជ្រើសរើសចូលរួមជាមួយការសិក្សានេះ លោកគ្រូ អ្នកគ្រូមានសិទ្ធមិនឆ្លើយសំណួរណាមួយ ឬបញ្ចប់ការឆ្លើយសំណួរនៅត្រង់ចំណុចណាមួយក៏បាន។

៤. ការទំនាក់ទំនងមកអ្នកស្រាវជ្រាវ

ប្រសិនបើលោកគ្រូ/អ្នកគ្រូមានសំណួរ ឬបញ្ហាណាមួយពាក់ព័ន្ធនឹងការស្រាវជ្រាវនេះ លោកគ្រូ/អ្នកគ្រូអាចទំនាក់ទំនងមកកាន់ខ្ញុំដែលជាអ្នកស្រាវជ្រាវតាមរយៈលេខទូរស័ព្ទ ០១៦ ៣៣២ ៧៧៥ ឬអាស័យដ្ឋានសារអេឡិចត្រូនិក mel.sereynivorth@nie.edu.kh ។

៥. កិច្ចព្រមព្រៀងក្នុងការចូលរួម

គោលបំណង របស់ការស្រាវជ្រាវបានពន្យល់យ៉ាងច្បាស់ដោយអ្នកស្រាវជ្រាវ ហើយខ្ញុំនឹងចូលរួមក្នុងការសិក្សាស្រាវជ្រាវមួយនេះ។ ខ្ញុំដឹងថា ខ្ញុំអាចឆ្លើយ ឬមិនឆ្លើយនូវសំណួរណាមួយ ដោយគ្មានពិន័យអ្វីទាំងអស់។

អ្នកចូលរួម	អ្នកស្រាវជ្រាវ
កាលបរិច្ឆេទ៖ ________________	កាលបរិច្ឆេទ៖ ________________
ហត្ថលេខា៖ ____________________	ហត្ថលេខា៖ ____________________
ឈ្មោះ៖ ______________________	ឈ្មោះ៖ ______________________

APPENDIX G

ឧបសម្ព័ន្ធ គៈ សំណើសុំធ្វើការសម្ភាសន៍ (សម្រាប់សិស្ស)

ខ្ញុំបាទឈ្មោះ **មុិល សិរីនិវត្តន៍** ដែលជានិស្សិតកំពុងសិក្សាថ្នាក់បរិញ្ញាបត្រជាន់ខ្ពស់ឯកទេសប្រឹក្សាគរុកោសល្យ នៅមជ្ឈមណ្ឌលស្រាវជ្រាវគរុកោសល្យជំនាន់ថ្មីនៃវិទ្យាស្ថានជាតិអប់រំ។ ខ្ញុំបាទបាន និងកំពុងធ្វើការសិក្សាស្រាវជ្រាវលើប្រធានបទ "**ការយល់ឃើញរបស់សិស្ស និងគ្រូចំពោះវិធីសាស្ត្ររៀនតាមបែបរិះរកដែលអនុវត្តចំពោះមុខវិជ្ជារូបវិទ្យានៅកម្រិតមធ្យមសិក្សាទុតិយភូមិ**" ដែលវាជាសារណាបញ្ចប់ថ្នាក់អនុបណ្ឌិតរបស់ខ្ញុំ។

១. គោលបំណងនៃការស្រាវជ្រាវ

ការសិក្សានេះមានគោលបំណងផ្តល់ជូននូវចរិកលក្ខណៈនៃការរៀនតាមបែបរិះរកដែលបម្រើឱ្យការអប់រំវិទ្យាសាស្ត្រជាមួយនឹងការផ្សារភ្ជាប់តួនាទីក្នុងការរិះរករវាងគ្រូ និងសិស្ស។ លទ្ធផលនៃការស្រាវជ្រាវនេះ នឹងបង្ហាញជូននូវព័ត៌មានចាំបាច់ដែលពាក់ព័ន្ធនឹងមធ្យោបាយនៃការដាក់ឱ្យដំណើរការវិធីសាស្ត្ររៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យាក្នុងបរិបទប្រទេសកម្ពុជា។ ជាពិសេសជាងនេះទៅទៀត ការសិក្សាស្រាវជ្រាវនេះនឹងចង្អុលបង្ហាញពីការយល់ឃើញពិតប្រាកដរបស់គ្រូនិងសិស្សចំពោះវិធីសាស្ត្ររៀនតាមបែបរិះរកចំពោះមុខវិជ្ជារូបវិទ្យារួមមាន លទ្ធផលជាផ្លែផ្កាក្នុងការសិក្សារបស់សិស្ស ក៏ដូចជាឧបសគ្គផ្សេងៗដែលរាំងស្ទះដំណើរការរៀនតាមវិធីសាស្ត្រមួយនេះ។ ការសិក្សាមួយនេះ នឹងជាផ្នែកមួយដែលរួមចំណែកក្នុងការលើកកម្ពស់ការបង្រៀន និងរៀនមុខវិជ្ជារូបវិទ្យាឱ្យកាន់តែប្រសើរ សម្រាប់ការអប់រំនៅប្រទេសកម្ពុជា។ លើសពីនេះ ការសិក្សានេះអាចនឹងក្លាយទៅជាឯកសារយោងសម្រាប់ការស្រាវជ្រាវបន្ថែមទៀតលើប្រធានបទស្រដៀងគ្នា ដែលនឹងផ្តល់អត្ថប្រយោជន៍ជាច្រើនដល់សិស្ស/និស្សិត គ្រូបង្រៀន ក៏ដូចជាស្ថាប័នពាក់ព័ន្ធ។

២. ដំណើរការនៃការស្រាវជ្រាវ

ប្រសិនបើអ្នកចូលរួមក្នុងការសម្ភាសន៍ នោះអ្នកនឹងត្រូវសួរនូវសំណួរមួយចំនួនទាក់ទងនឹងប្រធានបទស្រាវជ្រាវ។ ក្នុងសំណួរនីមួយៗអាចចំណាយពេលពី ៣ ទៅ ៥នាទី ដូចនេះការសម្ភាសន៍ អាចចំណាយពេលប្រហែល ៣០ ទៅ ៤០នាទី ហើយអំឡុងពេលសម្ភាសន៍ ខ្ញុំនឹងថតសម្លេងដើម្បីជាភាពងាយស្រួល។ ចំពោះឈ្មោះរបស់អ្នកនឹងមិនត្រូវបានបង្ហាញក្នុងការស្រាវជ្រាវទេ បើគ្មានការអនុញ្ញាតពី អ្នក ហើយការថតសម្លេងនេះគ្រាន់ជាជំនួយសម្រាប់ខ្ញុំក្នុងការបកស្រាយទិន្នន័យ។

៣. គោលការណ៍រក្សាការសម្ងាត់

ព័ត៌មានទាំងអស់នឹងរក្សាការសម្ងាត់ ដោយមានតែអ្នកស្រាវជ្រាវតែម្នាក់ដែលអាចប្រើប្រាស់បាន។ វាមិនមែនជាតេស្ត ហើយក៏គ្មានចម្លើយខុសឬត្រូវដែរ។ ព័ត៌មានរបស់អ្នក ពិតជាមានសារៈសំខាន់ណាស់សម្រាប់ខ្ញុំ ហើយខ្ញុំសង្ឃឹមថាអ្នក អាចចូលរួមជាមួយការសិក្សាស្រាវជ្រាវនេះ។ វាជាជម្រើសរបស់អ្នក បើទោះបីជាអ្នកចង់ឬមិនចង់ចូលរួមក៏ដោយ។ ប្រសិនបើអ្នក ជ្រើសរើសចូលរួមជាមួយការសិក្សានេះ អ្នកមានសិទ្ធមិនឆ្លើយសំណួរណាមួយ ឬបញ្ចប់ការឆ្លើយសំណួរនៅត្រង់ចំណុចណាមួយក៏បាន។

៤. ការទំនាក់ទំនងមកអ្នកស្រាវជ្រាវ

ប្រសិនបើអ្នកមានសំណួរឬបញ្ហាណាមួយពាក់ព័ន្ធនឹងការស្រាវជ្រាវនេះ អ្នកអាចទំនាក់ទំនងមកកាន់ខ្ញុំដែលជាអ្នកស្រាវជ្រាវតាមរយៈលេខទូរស័ព្ទ ០១៦ ៣៣២ ៧៧៥ ឬអាស័យដ្ឋានសារអេឡិចត្រូនិក mel.sereynivorth@nie.edu.kh ។

៥. កិច្ចព្រមព្រៀងក្នុងការចូលរួម

គោលបំណង របស់ការស្រាវជ្រាវបានពន្យល់យ៉ាងច្បាស់ដោយអ្នកស្រាវជ្រាវ ហើយខ្ញុំនឹងចូលរួមក្នុងការសិក្សាស្រាវជ្រាវមួយនេះ។ ខ្ញុំដឹងថា ខ្ញុំអាចឆ្លើយឬ មិនឆ្លើយនូវសំណួរណាមួយ ដោយគ្មានពិន័យអ្វីទាំងអស់។

អ្នកចូលរួម	អ្នកស្រាវជ្រាវ
កាលបរិច្ឆេទ៖ ____________	កាលបរិច្ឆេទ៖ ____________
ហត្ថលេខា៖ ____________	ហត្ថលេខា៖ ____________
ឈ្មោះ៖ ____________	ឈ្មោះ៖ ____________

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