Inquiry-Based Learning: an Effective Pedagogical Approach for Empowering 21st Century Learners and Education 4.0 in Thailand[1]

การเรียนแบบสืบเสาะหาความรู้: แนวทางการสอนที่มีประสิทธิภาพ เพื่อเพิ่มขีดความสามารถของผู้เรียนในศตวรรษที่ 21 และการศึกษา 4.0 ในประเทศไทย[2]

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Abstract

The two main factors, which have effects on education in Thailand, are the 21st century education and Education 4.0. The concept of the 21st century education has defined the pedagogical paradigm in Thailand for several years. Another factor, namely Education 4.0, has recently emerged as a result of the latest national economic development plan of Thailand. To succeed in learning, learners have to develop several skills, which are addressed as essential for living and working in the future. Thai teachers have

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been inevitably challenged by the changing trends of education. Based on the theory of constructivism, Inquiry-Based Learning (IBL) is suggested by educators as one of the effective pedagogy approaches for the 21st century education. This paper addresses the utilities of IBL and encourages Thai teachers to introduce IBL to their classrooms to promote Education 4.0 and the 21st century education at the same time. IBL principles and successful studies regarding IBL are discussed to guide teachers how to integrate IBL into classroom activities to help students acquire knowledge and gain necessary skills for living and working in the globalizing world.

Keywords Inquiry-Based Learning, the 21st Century education, Education 4.0, Thailand 4.0

บทคัดย่อ

ปัจจัยหลักสองประการที่มีผลต่อการศึกษาในประเทศไทย คือ การศึกษาใน ศตวรรษ ที่ 21 และการศึกษาระบบ 4.0 แนวความคิดของการศึกษาในศตวรรษที่ 21 ได้ กำหนดกระบวนทัศน์การสอนในประเทศไทยเป็นเวลาหลายปี หากต่อมาเมื่อไม่นานนี้มีอีก ปัจจัยหนึ่งได้ปรากฏขึ้น คือ การศึกษาระบบ 4.0 อันเนื่องมาจากนโยบายแผนพัฒนา เศรษฐกิจของประเทศไทยฉบับล่าสุด เพื่อให้ประสบความสำเร็จในการเรียน ผู้เรียนต้อง พัฒนาทักษะหลายอย่างที่จำเป็นสำหรับการใช้ชีวิตและการทำงานในอนาคต ครูไทยได้รับ การท้าทายอย่างหลีกเลี่ยงไม่ได้จากแนวโน้มการเปลี่ยนแปลงของระบบการศึกษา การเรียนรู้แบบสืบเสาะหาความรู้ (Inquiry-based learning: IBL) ได้รับการแนะนำจาก นักการศึกษาในฐานะที่เป็นหนึ่งในแนวทางการเรียนการสอนที่มีประสิทธิภาพสำหรับ การศึกษาในศตวรรษที่ 21 บทความนี้กล่าวถึงคุณประโยชน์ของการเรียนรู้แบบสืบเสาะหา ความรู้ และสนับสนุนให้ครูชาวไทยนำการเรียนแบบสืบเสาะหาความรู้ไปใช้ในห้องเรียน เพื่อส่งเสริมการศึกษาระบบ 4.0 และการศึกษาในศตวรรษที่ 21 ในขณะเดียวกัน หลักการ ของการเรียนแบบสืบเสาะหาความรู้และงานศึกษาวิจัยที่เกี่ยวข้องกับการเรียนแบบ สืบเสาะหาความรู้ที่ประสบความสำเร็จได้ถูกนำมาอภิปรายเป็นแนวทางให้ครูผู้สอนบูรณา การแนวการสอนนั้นเข้ากับกิจกรรมในชั้นเรียน เพื่อช่วยให้นักเรียนได้รับความรู้และได้ ทักษะที่จำเป็นสำหรับการใช้ชีวิตและการทำงานในโลกยุคโลกาภิวัตน์ต่อไป

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1. Introduction

Nowadays, students are required to fulfill certain knowledge and skills to succeed in working and living regarding the changes of educational principle. In Thailand, the concepts of pedagogical approaches have been geared toward the principle of the 21st century education for several years. Another factor, a so-called Education 4.0, which recently plays an important role of learning and teaching in Thailand, has been issued. Thailand 4.0 is the latest national economic development plan of Thailand, which focuses on the revolution of the industrial sector to accelerate economy of the country. As a result, education in Thailand, which serves as a key organization of producing human resources, has to gear toward Education 4.0.

The term education 4.0 firstly appeared in 2014 when Chulalongkorn University officially introduced a new pedagogical approach called Chula Engineering Education 4.0 to develop new innovators to serve the economic development plan ("Innovative thinking in the classroom Chula Engineering Education 4.0", 2015). To elaborate, Education 4.0 is an education plan of Thailand, which aims at creating innovators who can apply technologies and create innovations to increase values of goods and services (Puncreobutr, 2016, p. 94). The core principle of education 4.0 is equipping students with life-long skills that they can continually utilize for the whole life. Therefore, Education 4.0 is not just an education but it is also a process that helps students build essential skills for being innovators (Puncreobutr, 2016, p. 94). According to Sinlarat (2016, as cited in Puncreobutr, 2016, p. 95), the six skills to develop the future innovators in Education 4.0 are critical skills, cooperative skills, creative skills, productive skills, self and other understanding skills, and life-long learning skills. Besides, learning in Education 4.0 is no longer limited to classroom since there are supports of technology and the internet; as a result, learning can take place anywhere and anytime. In Education 4.0, teachers have shifted their roles in classrooms from lecturers to be facilitators who

promote learning community in which students are active learners and engage with peer experiences of learning (Fisk, 2017).

Noticeably, some of the students' skills emphasized as essences for working and living in the 21st century education are rather similar to students' skills for developing innovators in Education 4.0. The similar skills are critical thinking, problem-solving, communication, and collaboration (The Intellectual and Policy Foundations of the 21st Century Skills Framework, 2007). Furthermore, rather than serving just as information providers, 21st century teacher's role expands so that they may function more as guides, tutors, coaches, models, collaborators, innovators and researchers who are there to help students learn independently and to teach them how to use their time and resources efficiently and wisely (Stronge, Grant & Xu, 2015). The aforementioned roles are in line with teachers' roles in Education 4.0 that they are not lecturers but facilitators who assist students' learning. Since the array of students' skills required, schooling in the 21st century and Education 4.0 need a complete shift in thinking and approach for applying to classrooms to ensure that all students are learning and reaching their fullest potential. Teaching and learning in classrooms can be more efficient and attractive by applying pedagogical approaches, which aim to support the development of students' skills.

Inquiry-based learning (IBL) is one of the suggested approaches for learning and teaching in the 21st century era (Focus on Inquiry: A Teachers Guide to Implementing inquiry-based learning, 2004) since the approach has potential of developing students' skills, which are necessary for living and working in the future. Although studies have been devoted to applying IBL in classrooms, a few studies have discussed the utilities of IBL as an effective instruction for developing students' 21st century skills and Education 4.0 in Thailand. Therefore, this paper discusses the utilities and applicability of IBL implemented in classrooms to help teachers promote the 21st century education and Education 4.0 in Thailand.

2. What is Inquiry-based learning (IBL)?

Inquiry-based learning (IBL) or inquiry-based instruction is based on the theory of constructivism (Bruner, 1990; Rooney, 2012). Constructivism is concerned with the ways people construct knowledge, comprehend, and makes sense of things (Foley, 2012, p. 38). The learning processes of IBL mainly start with motivating students' curiosity on the topic they are interested in students generate questions (hypotheses) then explore, observe, acquire knowledge to answer questions as a process of learning (Pedaste, Maeots, Leijen, & Sarapuu, 2012). According to Castronova (2002, pp. 2-3), students actively participate in classroom activities, which assists students' learning since the learning activities appease students' curiosity and support individual interests. Similar constructs such as discovery learning highlight the process of students' learning rather than solely emphasizing students' learning outputs (Castronova, 2002, p. 3). According to Lee May (as cited in The Academy of Inquiry-Based Learning, n.d.), IBL is a pedagogical approach that fosters questions, opinions, and investigation through the process of learning. During this process, students are active learners while engaging with IBL activities since the activities motivate students to explore, observe, analyze, and learn in a challenging environment ("The Academy of Inquiry-Based Learning", n.d.). In other words, IBL encourages student-centered classrooms. While students are participating in IBL activities, they have the authority to determine processes and methods of acquiring knowledge to answers their questions. The process of IBL supports students' investigatory skills in collaborative environments. To elaborate, the process of IBL instruction offers useful practical experiences for students when they participate in classroom activities. Furthermore, IBL can be implemented in classrooms in four levels; (1) Confirmation level, (2) Structured level, (3) Guided level, and (4) Open level (Rooney, 2012, p. 130). The levels based on the degree of student autonomy in learning processes in classrooms. The following table proposes a description of each level of inquiry.

Table 1   Levels of inquiry

Level of inquiry	Description
Confirmation	Strongly teacher-directed. Questions, appropriate procedure of gathering information, beneficial information, tools, and also the result are provided to students by teachers. Teachers guide students throughout the learning process and correct students' decision and actions to assist them to finish the tasks.
Structured	Mostly teacher-directed. Questions, appropriate procedure of gathering information, beneficial information, and tools are still provided to students by teachers. At this stage, students are motivated to investigate, collect, and analyze the data to draw the answers of the suggested questions.
Guided	Mostly student-directed. The teachers propose some possible questions or hypotheses as guidelines. Students are motivated to select the questions or generate their questions/ hypothesis. Then, students are responsible for collecting and analyzing data to test them along with teachers' supports and mentoring.
Open	Strongly student-directed. Students themselves make a decision on questions/ hypothesis, procedure, and tool with the teacher's supports. The teacher can offer guidance, but students take the lead in the learning process.

Source: Adapted from Rooney. (2012, p. 130)

Moreover, another level of IBL implementation has been suggested; that is, couple level. Couple level is an implementation of two inquiry levels to classrooms phase by phase, for example, applying a guided inquiry phase followed by an open inquiry phase (Rooney, 2012, p. 130). These make IBL activities flexible and able to be integrated into various disciplines regarding vast integrating proportion to classrooms of the approach.

2.1   IBL framework

IBL has been implemented in classrooms and in various fields of education. Consequently, several models and learning cycles of IBL have

been utilized. This leads to some difficulties for teachers in making effective decisions in selecting which inquiry models are appropriate for their classrooms. Being aware of this issue, Pedaste et al. (2015) conducted a systematic literature review of articles regarding IBL and proposed an essential framework of the approach. As the authors explain, "the review of the 32 articles allowed us to generate an initial overview of the common phases across the articles and was the basis for proposing a comprehensive inquiry-based learning framework" (p. 51). Finally, the learning cycles of IBL normally consist of 5 main phases: orientation, conceptualization, investigation, conclusion, and discussion, with 7 sub-phrases: questioning, hypothesis generation, exploration, experimentation, data interpretation, communication, and reflection. To elaborate, Table 2 provides definitions of each main phase and sub-phrase.

Table 2   The definitions of each phase and sub-phase of the synthesized IBL framework

General phases	Definition	Sub-phases	Definition
Orientation	"The process of stimulating curiosity about a topic and addressing a learning challenge through a problem statement"		
Conceptualization	"The process of stating theory-based questions and/or hypotheses"	*Questioning*	"The process of generating research questions based on the stated problem"
		Hypothesis Generation	"The process of generating hypotheses regarding the stated problem"
Investigation	"The process of planning exploration or experimentation, collecting and analyzing data based on the experimental design or exploration"	*Exploration*	"The process of systematic and planned data generation on the basis of a research question"
		Experimentation	"The process of designing and conducting an experiment in order to test a hypothesis"

General phases	Definition	Sub-phases	Definition
		Data Interpretation	"The process of making meaning out of collected data and synthesizing new knowledge"
Conclusion	"The process of drawing conclusions from the data. Comparing inferences made based on data with hypotheses or research questions"		
Discussion	"The process of presenting findings of particular phases or the whole inquiry cycle by communicating with others and/or controlling the whole learning process or its phases by engaging in reflective activities"	*Communica-tion*	"The process of presenting outcomes of an inquiry phase or of the whole inquiry cycle to others (peers, teachers) and collecting feedback from them. Discussion with others"
		Reflection	"The process of describing, critiquing, evaluating and discussing the whole inquiry cycle or a specific phase. Inner discussion"

Source: Pedaste et al. (2015, p. 54)

An IBL framework is proposed according to the synthesis. According to Pedaste et al. (2015, pp. 55-56), three possible approaches to inquiry learning are suggested.

(1) Data-driven approach: Orientation–Questioning–Exploration–Questioning–Exploration–Data Interpretation–Conclusion (the loop between Questioning and Exploration can be repeated several times, but it is also possible to move directly from the first Exploration to Data Interpretation; Communication and Reflection can be added to every phase)

(2) Hypothesis-driven approach: Orientation–Hypothesis Generation–Experimentation–Data Interpretation–Hypothesis Generation–Experimentation–Data Interpretation–Conclusion (the loop between Hypothesis Generation–Experimentation–Data Interpretation can be repeated several times, but it is

also possible to move directly from the first Data Interpretation to Conclusion; Communication and Reflection can be added to every phase)

(3) Question-driven approach: Orientation–Questioning–Hypothesis Generation–Experimentation–Data Interpretation–(Questioning) Hypothesis Generation–Experimentation–Data Interpretation–Conclusion (the loop between Hypothesis Generation–Experimentation–Data Interpretation can be repeated several times, but it is also possible to move directly from the first Data Interpretation to Conclusion; after Data Interpretation it might be necessary to revise Questions, but more often only Hypotheses are revised; Communication and Reflection can be added to every phase)

The authors note that the orientation is a crucial stage of this framework since students will get basic concepts of the topics, which will be explored and raise students' curiosity to the topics. In other words, this stage should not be neglected. Regarding the three proposed pathways, each pathway has particular concepts of implementation. Data-driven approach is suitable for students who have no particular interest or he/she may have only basic knowledge of researching, whereas hypothesis-driven approach is appropriate for students who have particular theory-based ideas of what to explore (Pedaste et al., 2015).

"How people learn" is a fundamental principle in constructivism, which is based on the belief that learners construct their comprehension and knowledge through social experiences (Constructivism as a Paradigm for Teaching and Learning, 2004). Some educators, however, questioned the effectiveness of pedagogical approaches based on constructivism since the approach seems to be unguided or minimally-guided pedagogy. Kirschner, Sweller, and Clark (2006, pp. 4-5) expressed negative attitudes toward constructivism in a study regarding discovery learning, problem-based learning, and inquiry-based learning. According to them, constructivism tends to have pedagogical errors. They argue that the approach only emphasizes students' practicing without the concern of learning outputs (Kirschner et al., 2006, pp. 4-5). As a result, this leads to ill-prepared

instruction, which causes students' unpleasant experiences and incomplete knowledge acquisition.

However, such arguments against constructivism that it is an unguided or unprepared pedagogy seem to misinterpret the principles of the theory since the learning processes of IBL employ teachers' scaffoldings extensively while students are engaging the IBL activities. Hmelo-Silver, Duncan, and Chinn (2007) wrote an article to argue the claims. The authors point out some misunderstandings and wrong justifications of IBL in Kirschner et al. (2006)'s work. According to Hmelo-Silver et al. (2007), the pedagogical approaches based on the theory should be a well-organized cycle of instruction carefully designed and planned by teachers before implementation. In each stage of IBL, scaffoldings are employed to assist students, and this is able to reduce students' cognitive load while doing the activities (Hmelo-Silver et al., 2007, pp. 100-101). The key principles of the learning approach, namely IBL, are promoting students' learning skills and proficiency regarding the subjects implemented. The authors also note that IBL is not only helping students to gain new knowledge, which can be measured by achievement test but also allows them to gain "softer skills" such as epistemic practices, self-directed learning, and collaboration, which are crucial for being lifelong learners (p. 105). Lastly, Hmelo-Silver et al. (2007) argue that IBL is not minimally guided instructional approaches, but IBL is an approach "involve the learner, with appropriate scaffolding, in the practices and conceptualizations of the discipline and in this way promote the construction of knowledge we recognize as learning" (p. 105). In other words, IBL values students' intellectual development and students' skills development equally. It can be seen that the skills of students that have been developed during learning through IBL activities are the skills for students in the 21st century and Education 4.0 era. Hence, integrating IBL in classrooms to promote both trends of education should be taken into consideration.

3. Why utilize IBL in classrooms?

3.1 Offering discovery learning experiences

The key characteristics of IBL are that it is student-centered, self–directed, and involves active learning with teachers as facilitators. The approach is based on constructivism, which is a theory of teaching that learners construct knowledge for themselves. In addition, the IBL approach allows students to engage with materials in a meaningful way. According to the process of IBL which supports students' investigatory skills in collaborative environments, IBL is an authentic approach, which creates self-access learning situations for students. In other words, IBL can help students develop research skills, which are extremely important for being innovators. Gathering beneficial and reliable information on the interesting topics is not really an easy task; thus, students have to apply critical thinking and information literacy to select the pieces of information in order to develop new things or solve particular problems. Regarding the principles of Education 4.0 that students have to deal with the "harnesses the potential of digital technologies, personalized data, open sourced content, and the new humanity of this globally-connected, technology-fueled world" (Fisk, 2017), information literacy and digital literacy are crucial for students' learning. According to Chuenvinya (2011), the researcher proposed an instruction integrated INFOhio DIALOGUE Model and IBL to promote seventh-grade Thai students' information literacy. The results revealed the success of developed model in enhancing students' information literacy skills. Students know methods of accessing information, evaluating the reliability of information, and implementing information (Chuenvinya, 2011, pp. 126-128). Nowadays, the internet plays an important role as a channel that help access useful resources for education. Thai students usually use search engines such as Google to search for primary information; however, a minority of the students know how to use effectively search engines and only a few students concern about the quality of the gathered information before implementation in their works. Therefore, introducing IBL to

classrooms seems to be an appealing idea that Thai teachers should take into consideration.

Learning through IBL, students acquire knowledge through the process of asking deeper questions, finding supportive information, and solving problems. In other words, IBL requires students to be engaged with problem-solving, data-collecting, and researching a variety of sources. IBL has successfully promoted Thai students' research skills as there are examples of the studies. For example, Pilasombat (2016) proposed an instructional process based on IBL and situated learning approach to promote ability in conducting research in Thai teacher students. The results of her study showed that the students who learned through the developed instructional process had the ability in conducting research more than those who engaged with a tradition instructional process (Pilasombat, 2016, p. 112). This is the first beginning of equipping students' beneficial skills for being innovators in Thailand 4.0 era. In addition, students develop necessary skills to succeed in living and working when dealing with inquiry-based activities in classrooms. Adamson and Darling-Hammond (2015, p. 11) address the benefits and effectiveness of IBL in areas of teamwork and problem solving "Students engaged in IBL develop content knowledge and learn increasingly important 21st Century skills, such as the ability to work in teams, solving complex problems, and applying knowledge gained through one lesson or task to other circumstances". Students also increased critical thinking, interpersonal and life skills. The array of competencies learning and acquiring knowledge and content is vital to success in the globalized world. IBL activities can support the development of students' skills for being future developers and innovators which are the learning outcomes of Education 4.0.

3.2   Applying in diverse levels of education

The IBL approach promotes student-centered learning in various levels of age. According to the aforementioned four levels of IBL applied in classrooms, IBL can be employed in various ranges of education level, for

example, primary to university level. Teachers are responsible for determining the most appropriate level of IBL for their students. Furthermore, according to the adjustability of integrating IBL into classrooms, teachers are gradually able to adjust the level of IBL activities applied in a classroom if students are familiar with the learning process of IBL. Numbers of studies show the success of employing IBL in primary, elementary, undergraduate, and also postgraduate level (Albright, Petrulis, Vasconcelos, & Wood, 2012; Altstaedter & Jones, 2009; Horng-Yi, 2014; Hwang, Chiu, & Chen, 2015; Sabourin, et al., 2012; Seol, Sharp, & Kim, 2011; Siu Cheung & Yanjie, 2014). The adjustable degrees of IBL integration help reduce teachers' anxiety of first introducing IBL to their classrooms. In addition, the studies also emphasize the effectiveness of IBL for employing in different students' proficiency levels. That is, IBL has the possibility of being applied to many educational levels including disabled students. As appeared in a study, the results revealed the success of IBL used to develop intellectual performances of secondary school students who are mild to moderate intellectual and multiple disabilities (Miller & Taber-Doughty, 2014). The results of the study indicated all students were able to independently perform learning tasks and developed problem-solving skills (Miller & Taber-Doughty, 2014, p. 563). In other words, early introducing IBL in classrooms does not hinder students' learning but the approach helps teachers equip the 21st century skills since students are in early school age. Also, the scope of IBL used in educational contexts showed the applicability of IBL into all stages of higher education including foreign languages, social science, and physics to name a few (Spronken-Smith, 2012, pp. 10-11). Nowadays, IBL is integrated with technologies such as computer games, mobile phones, and websites to extend the applicability of the instruction to be outside classrooms. Game-based, mobile-based, and web-based IBL instructions are invented to offer new experiences of students' learning and discovering knowledge beyond classroom borders (Altstaedter & Jones, 2009; Hwang et al., 2015; Sabourin et al., 2012; Seol et al., 2011).

3.3   Encouraging interdisciplinary pedagogy

IBL has been utilized in science classrooms; however, this approach can be successfully applied to other disciplines such as second and foreign language learning, English for Specific Purposes, Social Science, research methods, and culture (Albright et al., 2012; Altstaedter & Jones, 2009; Horng-Yi, 2014; Hwang et al., 2015). On the other hand, IBL has been successfully applied to English language classrooms, interdisciplinary classrooms where a subject is taught in English, across all educational levels, and IBL has been shown to develop a wide variety of skills in addition to the desired content. For example, the successful study of Stoddart, Pinal, Latzke, and Canaday (2002) integrated IBL into a science classroom of Latino ESL students in California. The results showed the possibility of integrating science and English language acquisition by using English to develop an understanding of science content. According to the study, English language usage in authentic and concrete contexts can promote understanding of the science content, and could potentially be applied across other domains as well. Since education is no longer restricted to reading textbooks and doing exercises in classrooms, allowing students to engage with authentic experiences that they can apply their background knowledge and develop the new knowledge during the learning processes are more important. According to Fisk (2017), Education 4.0 is a new education principle, which aims to develop the essential array of students' competencies, skills, knowledge, and unlock students' creativity. As a result, teaching and learning in classrooms in which strictly emphasize a sole discipline might not be effective enough to support students' learning and acquiring knowledge. In each phase of IBL activity, it encourages students to be active learners in a collaborative learning environment. Students also learn how to monitor themselves to find supports and methods that help them to be successful in learning which is not rigid to one field. In addition, as several examples of studies revealed the efficiency of IBL in promoting interdisciplinary pedagogy, these address the plausibility of applying IBL in classrooms as learning activities

to enhance students' competencies and skills for working and life-long learning in the 21st century era.

4. IBL activity with mobile learning support

Nowadays, technology plays a significant role in this world. Even the educational field needs technology in teaching and learning since it requires innovation in this field. One of the common technologies, which have been applied in teaching and learning for many years, is e-learning. Presently, channels of the internet for learning come in a different form, namely mobile learning or m-learning. M-learning would be considered as the next generation of e-learning. Yet, m-learning is not the replacement of e-learning, but it is an extension of new educational contexts. It is the potentiality of providing teaching and learning contents on personal devices such as PDAs, smartphone, and mobile phones. Furthermore, the contents provided in m-learning refer to any form of digital resource accessed through personal devices (Mobile Learning Basics, n.d.).

M-learning can be incorporated with IBL to accelerate the effectiveness of IBL approach. According to Mobile Learning Basics (n.d.) and Saxena (2013), the mobile devices support learning experiences both inside and outside classrooms because students can use devices connected to the internet to access and record information, organize information, and work with peers anytime and anywhere. A few benefits of mobile devices in supporting IBL learning include operating multiple tasks at a time, gathering rich digital resources of data, supporting real-time interaction, maintaining students' interests and engagement, providing multiple data capture methods, reducing the amount of time and work, and allowing students to monitor their personal learning paces (Saxena, 2013). In addition, various applications are available for facilitating IBL at every phase. Saxena (2013) suggests several applications for supporting IBL activities such as YouTube, and BrainPop, which can be applied in the phase of motivating students' curiosity of lessons. Lino, Podcast,

and Evernote support students as in the roles of a problem solver, critical thinker, collaborator, communicator, and creator. Skype, Google Earth, Diigo, and Twitter can serve the objectives for the phase of collecting, gathering data, and collaborating with peers. Finally, Skitch, Socrative, Dropbox, Calendar, and Google Drive are beneficial for the synthesizing information phase (Saxena, 2013). These are guidelines for teachers who desire to integrate IBL with technology to raise the effectiveness of IBL.

5. Conclusion

The principles of the 21st century education and Education 4.0 play crucial roles in education in Thailand. Education has been geared toward the new perspective of instruction, which emphasize developing students' essential skills for learning and working in the future. Several areas of learning skills are proposed as necessary for the 21st century; however, four critical skills: collaboration and teamwork, creativity and imagination, critical thinking, and problem-solving are the most emphasized ("13 Essential 21st Century Skills for Todays Students", 2014). Besides, Education 4.0 in Thailand aims to develop innovators who have the knowledge of technology and use the knowledge to create innovations to empowering Thai Economy. As a result, education should not produce only high intellectual students but should also develop students who have vital skills in living and working in the global. Effective instructions are required to help Thai teachers equiping the skills to their students in classrooms to promote Education 4.0.

New pedagogical techniques and approaches, usually, are introduced to classrooms since teachers hope these will help to reach the educational goal. One of the teaching approaches, namely Inquiry-based Learning (IBL), which has been successfully introduced in classrooms is still effective enough to promote the 21st century education and Education 4.0. IBL has been suggested as an effective pedagogical approach of the 21st century education since the principles of IBL encourage students to practice and gain necessary

skills and new knowledge through the process of learning (Pedaste et al., 2012, p. 82). To elaborate, IBL is an approach which students are involved in learning, formulating questions, investigating the subject widely and then constructing new understandings and knowledge by themselves whereas teachers have the important role of facilitator. The roles of teachers in IBL align with teachers' roles in Education 4.0 since they are supporters and developers of innovators. Teachers help students to access beneficial resources and encourage them to learn. IBL empowers students to construct knowledge through student-centered discovery while they are cooperating in group work or pair work activities. Working with peers supports students' collaborative skills. Moreover, the cycle of IBL starts with generating questions relating to topics of lessons. Consequently, students work on the questions to find the answers or prove their hypotheses. Thus, students are able to gain critical thinking skills (Thaiposri & Wannapiroon, 2015, p. 2143) while engaging in the problem-solving activity of IBL activity. Also, the instruction is successful for interdisciplinary in diverse classroom contexts, for example, students' age and proficiency level. In general, students who learned through the process of IBL had experiences of acquiring knowledge, built up research skills, and prepared for life-long learning (Hmelo-Silver et al., 2007; Spornken-Smith, 2007).

Furthermore, the newly constructed knowledge is easily accessible to the students both inside and outside classrooms since the approach is now integrated with online technologies to be web-based, mobile-based, and computer-based activities. The effectiveness of IBL can be improved by incorporating technology to facilitate activities in each learning phase. On the other hand, the ways of introducing IBL integrating with technology also supports the principles of Education 4.0. Since classroom is no longer limited to a space between four walls, providing access to the internet anywhere are necessary for learning. Therefore, incorporating technology into pedagogical approaches is suggested.

In conclusion, IBL is an effective instruction for 21st century education and also has potential to support Education 4.0 in Thailand. While engaging in

IBL activity, students develop several skills, which listed as essential skills of 21st century education and Education 4.0. Supported by technology such as mobile learning, IBL can be improved and full potential to provide borderless classroom to students. Everywhere can be classrooms, as a result, this encourages students to be active learners and thinkers without the limit of time and place. With these supports, students are able to become innovators in the future. This article addresses the beneficial of IBL as classroom activities which greatly support developing students with array of essential skills in the 21st century and Education 4.0 era. Successful studies of applying IBL in several and various disciplines are discussed to suggest Thai teachers to reconsider using the approach in classrooms. IBL is no longer beneficial only for science subjects, but the approach can be adopted for teaching and learning in every field and every education level. Therefore, it is not tardy to consider introducing IBL and makes it practical in our classrooms; however, it is time.

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