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# CONCEPTUAL PAPER FOR FUTURE RESEARCH: EXPERIENCE OF STUDENTS IN PROBLEM-BASED LEARNING FOR SCIENCE IN A SECONDARY SCHOOL IN SABAH: A CASE STUDY

# KERTAS KONSEP UNTUK KAJIAN MASA DEPAN: PENGALAMAN PELAJAR DALAM PEMBELAJARAN BERASASKAN MASALAH UNTUK SAINS DI SEBUAH SEKOLAH MENENGAH HARIAN DI SABAH: SEBUAH KAJIAN KES

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**Abstract**: As an alternative, problem-based learning enables students to learn through real world issues, which differ from conventional teaching methods. The study aims to investigate the PBL approach (as suggested in Malaysia Education Blueprint 2013-2025), which is student-centered and has been employed in a real-life setting. From the literature review, students who learn through PBL possess the characteristics of self-directed and self-regulated learners who can collaborate and cooperate in learning. The setting is contextual, which promotes students' motivation. As a result, students acquired 21st-century skills (21CS), consisting of the cognitive, intrapersonal, and interpersonal domains. I am interested in exploring the characteristics of students who learn through PBL and how the process forms the characteristics of students, the involvement of teachers and how students deal with problem-solving, and the impact of interactions between students and teachers. A qualitative case study will be carried out in a secondary school in Sabah. This conceptual paper focuses on PBL, cooperative learning, and self-regulated learning using library research.

**Keywords:** Problem-Based Learning (PBL), Cooperative Learning, and Self-Regulated Learning.

**Abstrak**: Sebagai alternatif, pembelajaran berasaskan masalah membolehkan pelajar belajar melalui isu-isu dunia sebenar, berbeza dengan kaedah pengajaran konvensional. Kajian ini adalah untuk mengkaji kaedah pembelajaran barasaskan masalah (sebagaimana yang dicadangkan dalam Pelan Pembangunan Pendidikan Malaysia 2013-2025), di mana pembelajaran dalam keadaan dunia sebenar diterapkan secara berasaskan murid. Daripada tinjauan literatur, murid yang belajar melalui pembelajaran berasaskan masalah mempunyai ciri-ciri pelajar terarah sendiri dan pelajar terkawal sendiri yang berkolaborasi dan kolaboratif dalam pembelajaran. Keadaan pembelajaran yang kontekstual akan mempertingkatkan motivasi murid. Hasilnya, murid memperolehi kemahiran abad ke-21, yang terdiri daripada domain kognitif, intrapersonal,

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dan interpersonal. Saya berminat dalam meneliti ciri-ciri pelajar yang belajar menerusi pembelajaran berasaskan masalah dan bagaimana proses pembelajaran berasaskan masalah membentuk ciri-ciri murid tersebut, pneglibatan guru-guru dan bagaimana murid menghadapi penyelesaian masalah, dan impak daripada interaksi antara murid dan guru. Satu kajian kes secara kualitatif akan diadakan di sebuah sekolah menengah harian di Sabah. Kertas konsep ini berfokuskan pembelajaran berasaskan masalah, pembelajaran koperatif, dan pembelajaran terkawal sendiri dengan menggunakan kajian perpustakaan.

**Kata kunci:** Pembelajaran Berasaskan Masalah (PBL), Pembelajaran Koperatif, dan Pembelajaran Regulasi Kendiri.

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## INTRODUCTION

Due to the reason science has become more and more important these days, adding to that, science education is facing fierce challenges economically and socially, changes are inevitable, and it is happening (Trna & Trnova, 2015). Three major concepts have been put forward for the changes in science education. Namely, the need for awareness, the importance of interdisciplinary education from the science contexts, and how to trigger and nurture science interest in real-life, daily activity, or environment. Science is influencing the job market globally. Scientific literacy is the term used globally by educational institutions to illustrate and describe an individual's abilities related to science to benefit the economy, society, and nation (Al Sultan et al., 2021).

Considering the above studies, the objective of the science subject in Standard Based Curriculum for Secondary Schools (KSSM) for form 4 and form 5 (SPM) has been apparent. It states that, through inquiry approach, dialling up student's curiosity and interest in science, enhancing their knowledge through connection with daily events and application of scientific knowledge. Problem-solving and decision-making skills have been highlighted (Bahagian Pembangunan Kurikulum, 2019). Furthermore, research shows that problem-based learning (PBL) is very effective in knowledge retention (due to the process of PBL) and also superb in knowledge application in real-life situations (Yew & Goh, 2016).

While the world is developing rapidly in technology, teaching science also needs to revolve around the development of technology (Yorkovsky & Levenberg, 2021). Emphasis is also on the connection between what has been learned in science (scientific literacy) and real life. There should not be any separation between studies (knowledge and thinking skills) and applying what has been studied into the daily application for the development and welfare of surrounding society. I have noticed that, in the PBL environment, students find the connection between "textbooks" and the actual surrounding world. Conversations between students and teachers involved in PBL give the insight that students had a vast opportunity to apply what they learn in the classroom to a real-life situation. According to Montepara et al. (2021), PBL enables students to apply their knowledge (which are the information they had learned) to their practices (which are real-life situation).

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According to Lonergan et al. (2022), PBL has been adopted more frequently for secondary school because PBL can enhance or encourage students to apply their knowledge in solving real-world problems.

**Statement of Problem**

Students who learn through PBL possess the characteristics of self-directed and self-regulated learners who can collaborate and cooperate in learning. The setting is contextual, which promotes students' motivation. As a result, students acquired 21st-century skills, which can be viewed from three domains which are cognitive (critical thinking, reasoning, and argumentation), intrapersonal (motivation, beliefs, metacognition, and self-regulated learning), and interpersonal (effective communication and responsibility).

It is essential to understand the process of PBL, which take place in a secondary daily school setting, which is very different from the PBL in the literature, which took place in higher education from a different field that prepared their students to become professionals. The intentions are to provide rich data for educators who serve at the secondary school level, especially in science, to understand PBL better and embrace PBL in the teaching and learning of science.

## REVIEW OF LITERATURE

Malaysia's education system has shifted from emphasizing reading, writing, and arithmetic (3M) to higher-order thinking skills (Kementerian Pendidikan Malaysia, 2013). These aspirations set the stage for our Malaysian students to meet the 21st century's challenges in the economic field of this rapidly changing world. The National Science Education Philosophy aligns with the National Education Philosophy in stating that Malaysia's science education aims to nurture a science and technology culture. In order to achieve the aim, the development of competitive, dynamic, robust, and resilient individuals who master scientific knowledge and technological competency need to be the focus (Bahagian Pembangunan Kurikulum, 2018).

Going into the detail, at the school level, to deliver the aim and focus of National Science Education Philosophy, the aim of KSSM (Standard Curriculum for Secondary Schools) for science has been authored to strengthen the interest and to develop creativity among pupils through the process of experiencing and investigating. This process enables students to master science knowledge, scientific skills, and thinking skills and embrace scientific attitudes and values. Through the application, students can solve problems and make decisions in their daily life (Bahagian Pembangunan Kurikulum, 2018).

The development of students has been focused on three domains: knowledge, skills, and values, to equip and prepare them for the challenges of the 21st century. One of the intentions of KSSM for Science is to equip students with 21st-century skills (21CS). The acquirement of 21CS has become increasingly important due to the changes in the education landscape, globalization, and people getting increasingly inter-connected (Teo, 2019). To attain the aim, PBL has been suggested as one of the teaching and learning strategies for science in secondary school (Bahagian Pembangunan Kurikulum, 2018).

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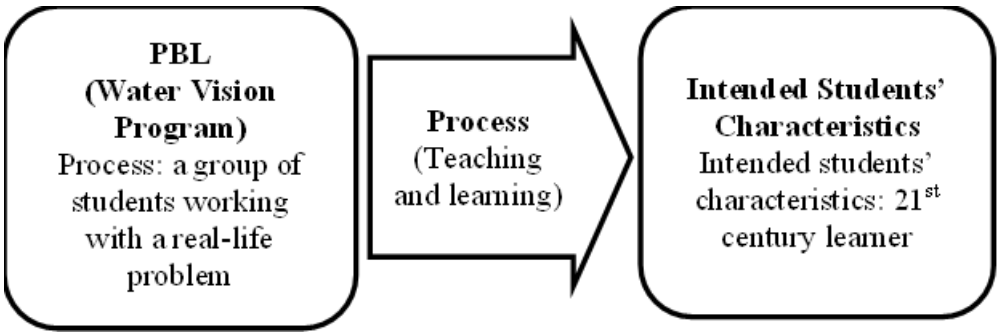


Figure 1: Framework for PBL's Process in Fostering 21st Century Learner

**Problem-Based Learning**

PBL is a learning strategy that provides an environment where students actively participate in the learning process by understanding why and what they are learning and dealing with real-life issues. The scenario keeps students motivated at a high level (they are curious about what are the solution to the problems) to keep on researching until they reach the said goal (Hatısaru & Küçükturan, 2009; Bidokht & Assareh, 2011). Water Vision Program, which is held yearly, provides the PBL's platform of learning for students to learn. The program requires the participants to target a real-life issue related to water quality. Applying their knowledge in science to propose a solution, present it, and create awareness among the community where the issue has been identified.

The starting of PBL, tracing back to the mid of 1960s, is an alternative teaching method introduced to meet medical students' needs and aimed to enable the students to acquire skills relevant to the issues in the real world. The teaching method is student-centred, and the real-life setting is the platform for learning (Loyens et al., 2008; Kwan, 2019). Due to these natures of PBL, it fits nicely into today's education landscape. In today's education landscape, students are nurtured in the direction of 21st-century learners. 21st-century learner refers to those who possess communication, collaboration, and critical thinking skills (Teo, 2019).

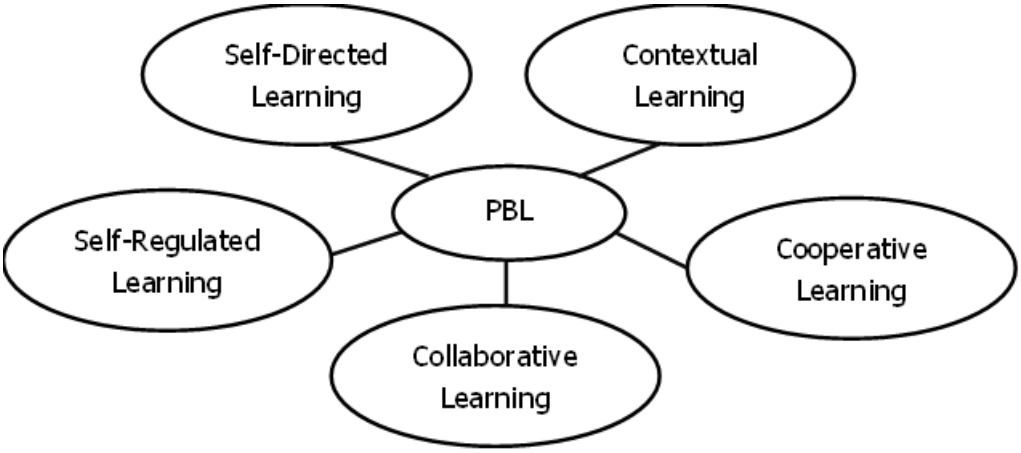


Figure 2: Components of Problem-Based Learning

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The five main components of PBL that will be looked into during this study are self-directed, self-regulated, collaborative, cooperative, and contextual learning. As a conceptual paper of doctoral degree research in progress, two components of PBL will be included and discussed, namely self-regulated learning and cooperative learning. The objective of conducting PBL in a government secondary school setting is to produce students with 21st-century skills, and 21CS will also be included.

Many pieces of research show that PBL contributes to developing 21SC among learners. Sabatana and Dudu (2021) found that implementing PBL in science (chemistry) enhances communication and critical thinking skills. The finding has been supported by Aslan (2021) and Lonergan et al. (2022). According to Aslan (2021), students who learn through PBL from live online classes show better achievement in learning, acquire a better and higher level of problem-solving skills, and have more communication during classes. Another similar finding by Lonergan et al. (2022) shows that students who go through PBL possess better topic knowledge and problem-solving skills. Students also show better self-regulation to obtain learning goals.

On top of the above research, Montepara et al. (2021) found that pharmacy students in Italy who participated in PBL would like to participate in PBL in the future if they are given a chance to do so. The study's finding shows that the students benefit from PBL for their professional development through collaboration with pharmacy students from other countries. Through this activity, through the reflection from the students, they can apply what they have learned to real-world situations (simulation for their future practices). The study also opened up the opportunity for PBL to be intergraded into Italy pharmacy school curriculum. This shed light on the research which is going to commence. It is believed that the finding will encourage more teachers in this country (especially in Sabah) to embrace PBL.

**Self-regulated learning**

A self-regulated learner is a student or learner who is actively participating in their learning from a few aspects such as the aspect of setting their own learning goals, cognitive and metacognitive aspect, motivational aspect, and the behavioural aspect in order to attain the set goal himself/herself (Kuo et al., 2014: Tsai et al., 2009; Yilmaz et al., 2020). Learners need to have awareness (monitoring) of the knowledge and skills needed for the process, and the awareness causes them to take necessary action to acquire the necessary knowledge and skills (Sailer et al., 2021; Yilmaz et al., 2020). Learners must be trained to set their own learning goals, monitor their progress, and manage their resources and motivation to stay focused (Guo, 2022).

From the metacognitive aspect, the learner must be able to monitor and evaluate the learning process by setting up a learning plan or setting up the goals that need to be achieved at a particular time, including setting up a timetable to monitor their progress when time passes by. The self-judgment process comes in here as the learner compares the present level of performance with the goal which had been set to be achieved at the end of the learning process (Rajabi, 2012). Guo (2022) has found that self-monitoring is an approach that is effective in promoting an

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academic performance by promoting the strategy which has been used to promote academic performance.

In the motivational aspect, the learners are in charge and willingly take responsibility for the success or failure of their learning. Lastly, in the behavioural aspect, during the learning process, the learner will undoubtedly face some problematic tasks that are difficult to solve. One of the behaviours seen in a self-regulated learner is seeking help from others. The learner can gain optimal or maximum gain from the learning process (Kuo et al., 2014). Adjustments to learning behaviours will be made by the self-regulated learner at the end of each learning circle (definition of learning task, setting of learning goal, selection of strategy, and reflection and adaptation) (Raković et al., 2022).

From the research done by Alotumi (2021), the result shows that for students to cultivate their learning motivation, motivation regulation training needs to be incorporated to heighten the awareness regarding motivational self-regulatory strategies. Similar finding by Ilishkina et al. (2022). Ilishkina et al. (2022) found that to be a successful learner, and one should be able to self-regulate their motivation to learn. To help students choose appropriate motivational regulation strategies, their awareness of their learning motive is crucial. Teachers need to help students to obtain awareness, both intrinsic and extrinsic. The research finding shows that intrinsic and extrinsic motives can be distinguished. Intrinsic motivational regulation strategy targets interest, personal significance, and mastery orientation. Extrinsic motivational regulation strategy targets performance-approach/performance-avoidance orientation, goal setting, self-consecrating, and environmental control. A teacher needs to make students aware of their learning motives so that students can make correct choices of motivational regulation strategies to benefit their learning.

As a component of PBL, self-regulated learning is closely related to the intrapersonal domain of 21st-century learners (Alotumi, 2021; Ilishkina et al., 2022; Rajabi, 2012). It can be seen from the accountability of learners' learning outcomes. The intrapersonal domain of 21CS talks about the ability of an individual to achieve the learning goal by proper management of own behaviour and emotions. This aspect has been seen in self-regulated learning, such as setting own learning goals, cognitive and metacognitive, motivational, and behavioural aspects.

**Cooperative learning**

Cooperative learning is a type of constructivism (Lin, 2013). It is based on the theory proposed by Vygotsky, in which the learning process consists of internal structuring of external social activities, and it is the foundation for PBL (Raviv et al., 2019). The learning process that the learner goes through is in the form of negotiation and solving conflict. At the same time, they must listen actively to their group members (it focuses on interaction), mutual listening, and exchanging knowledge (Lin, 2013; Raviv et al., 2019). Learning is a process where the learner is actively involved with the task they need to solve, and interaction needs to happen actively with other individuals in the group, known as group members. It enables the learner to be exposed to different perspectives from different individuals, and every individual has their idea about situations and solutions to problems (Lin, 2013). Commitment is demanded from every group member because

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they are mutually dependent, sharing equal opportunities and mutual responsibilities in a cooperative environment in which communication is essential (Raviv et al., 2019).

Three dimensions that are essential to be taken into consideration for group work: are cognitive, social, and affective. The cognitive (content) aspect is the problem to be solved, which is scientific knowledge. The challenge which exists due to social interaction within the group is the social (interaction) aspect. Emotional attachment is the affective aspect (Nieswandt et al., 2020). Hogenkamp et al. (2021) also suggest that when students work together in a group while engaging in a cooperative learning activity, attention should be given to cognitive, behavioural, and motivational aspects.

There are differences between the terms cooperative learning and collaborative learning, which are usually used interchangeably. Usually, these two terms are referred to the learning styles which involve a small group of learners who have been placed together (group work) for a specific learning task (Nieswandt et al., 2020). There is a clear and specific division of work or labour between group members for cooperative learning. In the problem-solving process for group learning, each member in a cooperative learning group has their responsibilities, contributions to make, and tasks to be completed (Gukkurt et al., 2012; Lin et al., 2013; Nieswandt et al., 2020; Ruengtam, 2013). Therefore, learners in the group will share their opinion and materials (encouraged to communicate), and work is distributed equally among the group members (Gukkurt et al., 2012; Raviv et al., 2019).

Cooperative learning has been related to promoting students' emotional intelligence grounded in emotional competencies such as self-awareness, self-regulation, motivation, empathy, leadership, and social skills. Meanwhile, emotional competencies are related to students' academic performance (Fernandez-Perez & Martin-Rojas, 2022). Emotional competencies are affecting individual's adaptation ability to an environment, according to the theories of Emotional Intelligence (Fernandez-Perez & Martin-Rojas, 2022). Students with better emotional intelligence are better at working and cooperating with others in the PBL group. Teamwork capability can be promoted through cooperative learning. Teamwork capability has been highlighted for its importance in promoting students' learning and the other students' (small) cooperative learning group (Fernandez-Perez & Martin-Rojas, 2022). To get these competencies to be promoted effectively (students acquiring these competencies), the learning-teaching process needs to be appropriately designed for students to actively participate in the task given (Fernandez-Perez & Martin-Rojas, 2022). It is why PBL, consisting of cooperative learning, is a strategy emphasized by KPM to promote 21st-century skills.

To define emotional competencies, one must consider a person's self-awareness, self-regulation, motivation, empathy, leadership, and social skills. Self-awareness is the awareness regarding oneself in emotions, self-confidence, and accurate self-assessment. The importance of self-awareness has been widely recognized in various fields. As for education, this awareness helps the student to recognise (detect) the important emotional information from within themselves and the surrounding environment. It will lead the student to the point of realizing one's values and passion by adopting various cognitive actions (Fernandez-Perez & Martin-Rojas, 2022).

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Study shows that through cooperative learning, the learner will improve their social skills such as dependence, support for mutual tasks, teamwork, attaining success, determination toward success, problem facing, communication, problem-solving, decision making, self-management, and ability to interact with others (giving an opinion, accepting others' opinion) (Chen et al., 2012; Haliza Othman et al., 2012; Raviv et al., 2019; Pawattana et al., 2014). Besides, cooperative learning will also promote students' involvement in observation and provide the necessary support for their group members (Haliza Othman et al., 2012). Peers usually work and operate within each other's zones of proximal development. Peers might be contributing slightly higher or advanced thinking, which might assist one another (Slavin, 2006). Hence, cooperative learning establishes the foundation for the PBL method, which is challenging and gives students a meaningful learning experience (Raviv et al., 2019).

Learning is the process where the learner himself is the knowledge constructor. Cooperative learning enhances the knowledge constructing process for a learner, resulting in improved learning gains (Tadesse et al., 2020; Lin, 2013; Fung et al., 2012). In cooperative learning, the students are made to understand that in order for them to be successful as a group, they need to meet the following four points, namely positively interdependence, interaction among group members, individual accountability, and interpersonal skills. These four criteria are necessary for the group's functioning (Lin, 2013). According to Tadesse et al. (2020), through cooperative learning, a positive relationship has been shown between the challenge of learning, interaction (in the form of cooperation), learning gains, and satisfaction of learning.

Peña-Ayala (2021) has found that a cooperative learning framework is better than a conventional learning framework when featuring 21st-century education. Tadesse et al. (2020) also found that cooperative learning is associated with a higher perception of cooperative interaction and learning gains. Besides that, positive relation has also been shown between cooperative learning and students' overall satisfaction. Another research by In'am & Sutrisno (2021) shows that cooperative learning can strengthen students' self-efficacy and motivation in learning (mathematics). A similar result has also been found by Torrijo et al. (2021), showing that cooperation enhances students' motivation and learning engagement. Improvement has been observed in teamwork, communication effectiveness, and critical thinking. Thus, as a component of PBL, cooperative learning provides the platform for the learner to attain 21CS.

Zhang and Chen (2021) have found that cooperative learning, which takes place in nursing students' clinical practicum, is effective in promoting critical thinking within students. It is in line with the research purpose of looking into the PBL process in the Water Vision Program that has been viewed by researchers as able to promote 21CS (critical thinking skill in the cognitive domain).

While many pieces of research show significant benefits regarding cooperative learning in contributing toward the formation of 21st-century skills in learners, Liebech-Lien (2021) raised the concern of the challenges teachers face while practising cooperative learning. The study found that teachers must have a collaboration team to learn and explore the implementation of cooperative learning, rather than go through the professional development program and break up

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with the team, go back to where they work, and find no support at their workplaces. This finding illuminates the area to investigate for this research.

**21st Century Skills**

Due to the evolution of the nature of the job market, which has been influenced by automatization, digitalization, and globalization, 21st-century skills are the competencies and attributes of current and future citizens (Webb et al., 2018). The model of education, which has been structured for the industrial-nineteenth century, is no more capable or suitable to develop global citizens in this inter-connected world (precariously changing) that demand a new type of self-management and new skill set (McPhail, 2020). The current global education is on transformation, equipping students with 21CS that enable them to cope with the complexity of current society – by utilizing their knowledge to solve real-life problems (Haug & Mork, 2021). It is shifting from the old three R's (reading, writing, and arithmetic) to the new three R's (rigor, relevance, and real-world skills) (Teo, 2019).

21st-century skills set can be categorised into cognitive skills, interpersonal non-cognitive skills, and intrapersonal non-cognitive skills (Haug & Mork, 2021; Wright & Lee, 2014). Cognitive skills (or cognitive domain) include deep learning, computational and information literacy, adaptability, creativity, critical thinking, systems thinking, and problem-solving are examples of cognitive skills (or cognitive domain). Communication, cultural sensitivity, leadership, and teamwork are examples of interpersonal non-cognitive skills which enable an individual to relate to others. Persistence, self-efficacy, time management, and work ethic are examples of intrapersonal non-cognitive skills which reside within oneself (Haug & Mork, 2021; Wright & Lee, 2014; Bao & Koenig, 2019; Teo, 2019).

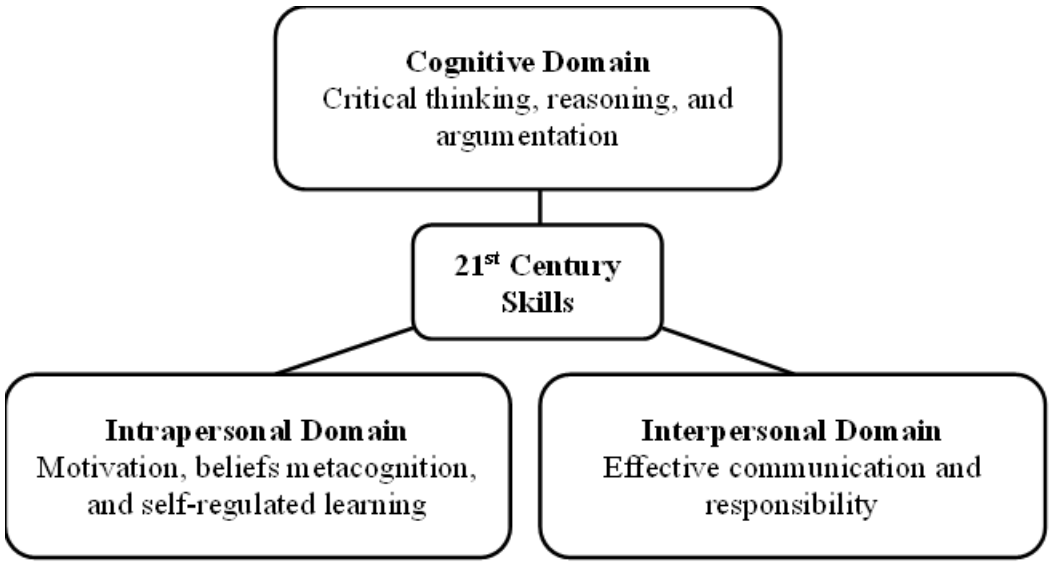


Figure 3: Three Domains of 21st Century Skills

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## METHODS

Time has been spent exploring online resources – journals from Universiti Malaysia Sabah's library off-campus access (from https://login.ezproxy.ums.edu.my/loggedin/database.html), through ProQuest, ScienceDirect, Scopus, and SpringerLink. Searching also for the publications by Malaysia Education Ministry (KPM): Malaysia Educational Blueprint 2013 – 2025 and Standard Curriculum for Secondary School (KSSM) for science subjects from Curriculum Development Division's website (from https://www.moe.gov.my/en/muat-turun/penerbitan-dan-jViurnal/terbitan). Water Vision Sm. St. Michael, Penampang 2015's Facebook page (from https://www.facebook.com/Water-Vision-Sm-St-Michael-Penampang-2015-1569679786615566) and Malaysian Nature Society's Water Vision 2020's website (from https://www.mns.my/water-vision-programme/water-vision-2020/), for an insight of PBL as the case which is going to be studied.

## CONCLUSION

This conceptual paper discussed about the PBL which been suggested in Malaysia Education Blueprint 2013 – 2025 and students with 21CS as the objective of KSSM. Cooperative learning and self-regulated learning as the components of PBL been discussed and reviewed. The findings from previous research in cooperative learning and self-regulated learning been analysed and synthesized. These components of PBL shows contribution to the formation of 21st century skills in learner. In self-regulated learning, learners are accountable towards own learning outcomes, knowing which motivational regulation strategies to adopt by knowing oneself learning motives – contribute to intrapersonal domain of 21CS. In cooperative learning, learners develop 21CS from cognitive and interpersonal domains. 21CS been viewed from cognitive domain, intrapersonal domain, and interpersonal domain. Exploration through library research will continue into the others three domains of PBL, which are self-directed learning, collaborative learning, and contextual learning.

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