

Project-Based Learning in Preschool Science Education

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Abstract

Science education is important in supporting the country's goal in achieving its developed nation status by the year 2020. However, it has been reported that fewer students have chosen to pursue science subjects. Among the underlying causes identified was due to ineffective traditional teaching strategies and approaches. Project-based learning (PBL) is a model for a classroom activity that shifts away from the usual classrooms practices of short, isolated, teacher-centered lessons. PBL learning activities are long-term, interdisciplinary, student-centred and integrated with real-world issues and practices. Project-based learning in science includes a context that engages students in extended authentic investigations through driving questions, collaborative work that allows students to communicate their ideas, learning technologies to find and communicate solutions, and the creation of artefacts that demonstrates students' understanding. The study aims to identify the benefits of project-based learning in preschool science education.

Keywords: Project-based learning, Science, Pre-school, Science education.

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Introduction

Strengthening of Science, Technology, Engineering and Mathematics (STEM) initiatives outlined in the Malaysia Blueprint 2013-2025 aims to ensure students to be well-equipped with the necessary skills to meet the challenges of the 4th industrial revolution. STEM is a programme designed to develop practical skills such as critical thinking, collaboration and communication which were required in the 21st century. It is a curriculum based on the idea of educating students in four specific disciplines – science, technology, engineering and mathematics. Rather than teaching the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications. Therefore, teachers must be equipped with the knowledge and teaching approach for STEM education from pre-school to post-secondary (Azian 2015). This is to ensure that the mindset towards STEM fields can be cultivated and sown from early schooling level.

Students' performances have deteriorated because of the difficulty of science subjects as they could not relate what they have learnt to a real-life scenario. Teachers using ineffective traditional teaching strategies or approaches also caused students to be unable to understand what they were taught truly. Thus, resulting in the lack of 21st-century skills-collaboration, communication, critical thinking and creativity.

One of the challenges of education is to teach a student who has various capacities and different learning rates. Another challenge faced by Iwamoto et al. (2016) using a traditional teaching model was that increasing amount of students lost interest after about 8 minutes into the lecture. Teachers are expected to teach using an approach that allows the student to master concepts of science and at the same time, acquire the higher-order thinking skills (HOTS). Various strategies have been introduced in the teaching of science classrooms, from the teacher-centred approach to a student-centred approach.

Their academic achievements still reflect students' ability and capability today. School management depends on tests and other

traditional academic assessments to evaluate skills that do not necessarily prepare students with what they need for success in the real world. Academic results are still emphasized since young, and the students are learning how to memorize to sit for tests and examinations, and they are not being asked to think critically, analyse, ask questions or prepare for life after high school. The need to use of multi-faceted approaches to deliver content and to develop soft skills among Malaysian students is outlined in the national curriculum. To fulfil this need, the Ministry of Education has implemented "Making School Smart" programme for all Malaysian schools under the Ninth Malaysian Plan (RMK-9). The programme aims to integrate teaching and learning with technology. Project-based learning (PBL) is used to achieve the 21st-century skills, activity-based learning to encourage self-directed, self-paced and self-accessed learning among students (Educational Technology Division 2006).

For science teaching in early childhood, engagement in science activities requires a strategy that helps to expose the understanding of children. Educators have emphasized on the importance of building students' understanding of science subjects for decades. Dialogue on science activities can also expose children's questions and ideas, such as allowing children to interact with science phenomena, allowing children to understand the understanding of their emerging curiosity towards science (Siry & Kremer 2011).

Due to students' different learning styles, cultural and ethnic background, prescriptions of either a "one-size-fits-all" approach do not necessarily gear them towards achieving high standards. Project-based learning is touted to be the approach and means to achieve the 21st-century skills which consist of the 4C's: critical thinking, creativity, collaboration and communication (Educational Technology Division 2006).

The study aims to identify the benefits of project-based learning approach in science education. Research questions that will be answered in this paper are:

- i) What are the benefits of project-based learning approach on students' learning outcome in science?
- ii) How does project-based learning approach affect the academic of the students in science subjects?

Literature Review

Theory

In Malaysia, the National Preschool Curriculum 2003 (KSPK) was revised and eventually, the National Pre-School Standard Curriculum was developed and implemented from 2010 to all government and non-government pre-schools. This is to fulfil current needs in line with the National Transformation Program. The National Preschool Standard Curriculum is built on the principles of Practice in Conformity with Development and constructivism learning theories. KSPK emphasizes thinking skills, aspects of health and personal safety and the identification of relationships with the international community. Appropriate theories implemented in kindergarten are like Constructivism Theory, Gardner Intelligence Diversity Theory, Vygotsky Cognitive Development Theory, Jean Piaget's Cognitive Development Theory, Bandura Social Learning Theory, and Bronfenbrenner's Ecological System Theory. The approaches that practice relevant theories are like play-based learning, project-based learning, cooperative learning, student-centred learning, thematic approach, and so on. Among the types of games are such as the solitary game, parallel, associative and cooperative games where each has their activities that need to be diversified by teachers in developing the dimension of the development of pre-school children.

Project-based learning (PBL) is based on several learning theories such as the theory of constructivist learning by Piaget (1952), Vygotsky (1986) and Bandura (1971), learning through Dewey (1938) and constructionism theory by Papert (1980). The mental model constructed by the students themselves in developing an understanding of their environmental world is fundamental to the project-based learning approach (Papert 1980). Through the products or artefacts produced at the end of the learning, a more effective outcome on PBL will be created. Project-based learning will be more effective when it is integrated with technology and combined with collaborative learning with their colleagues. Students will be more motivated and always motivated by curiosity when learning using the PBL method, which is a kind of open-ended inquiry learning.

Wurdinger & Rudolph (2009) described the constructivist approach to teaching by suggesting that knowledge is gained through experiences. The theory centres around the assumption that learners construct knowledge and meaning for themselves through actions and activities. People construct meaning through experiences instead of concentrating on remembering and trying to understand. This concept relates to the Constructivist Theory; it is founded on the idea that students will better understand the world around them through learning actively, socially, physically, verbally, cooperatively. The theory explains that learning by doing and therefore, understanding creates a deeper awareness of the real world. Project-based learning is a specific method that provides such learning opportunities and also presents learning in multiple ways. Gardner's Theory of Multiple Intelligences presents the notion that all students learn differently (Gardner & Moran 2006). Gardner's theory proposes seven primary forms of learning which include linguistic, musical, logical-mathematical, spatial, body-kinaesthetic, intrapersonal and interpersonal. His theory explains that when teaching, lessons should be designed around the multiple intelligences of the students. PBL is a planning method that allows teachers to create a curriculum with students' multiple intelligences and needs for learning in mind. Students need a variety and freedom to learn, especially through ways that work best for them individually.

Project-based learning is an investigative activity that helps to develop cognitive structures and reconstruct knowledge following the perspective of Piaget's cognitive development. In project-based learning, students are allowed to create products following their cognitive power, artistic talents and presentation skills in the process

of the project. It provides to explore a topic in depth. Students use their scientific process skills by observing the weather, reading and interpreting maps, generating data, conducting on research-based activities, manipulating the materials and improving self-regulation and self-evaluation skills on projects. All these activities based on constructivist learning environments help the student to gain meaningful experience during the learning process (Ilhan 2014). Constructivist action-teaching methods lead to student-focused teaching. The constructivist perspective views learning as an experiential process. Active learning strategies engage students by having them learn through discovery. This student-focused approach has been shown to promote deeper learning in students resulting in higher quality outcomes and grades (Iwamoto et al. 2016).

Importance of Pre-School Science Education

Science education is important in supporting the country's goal to achieve developed nation status by the year 2020. Various policies have been introduced in Malaysia, including the National Science and Technology Policy (NSTP) and NSTP II by the Ministry of Science, Technology and Innovation (MOSTI). NSTP is designed to make Malaysia a competent, independent and inventive in science and technology by 2020. NSTP II highlighted several key areas and one of which states the need of adoption of 60:40 ratio of students pursuing science, technology and engineering disciplines in upper secondary schools and universities than in the field of literature. (MOSTI 2010). Moreover, according to the Malaysia Deputy Minister of Science, Technology and Innovation, Dato' Dr Abu Bakar Mohamad Diah (22 April 2017), raised his concern about the number of science students recruited is less than expected, which is the ratio 20:80 of science stream students compared to art stream students instead of a plan which is of the ratio 60:40.

The Ministry of Education (MOE) reported that 15% of students who met requirements chose not to pursue science in the upper secondary school (Azian 2015). Among the factors underlying the declining enrolment and quality of student outcomes in STEM is limited awareness about STEM, perceived difficulty of STEM, content-heavy curriculum, inconsistent quality of teaching and learning and limited and outdated infrastructure. The government has since introduced several programmes and enhancement projects for the Malaysian education system. One of the enhancements done is by introducing the Higher-Order thinking skills, project-based, ICT games-based in the new primary and secondary curricula.

Maintaining the interest of students from pre-school and primary level in science education is vital in order to encourage more students to pursue a science and engineering-related career. The National Education Philosophy has emphasized on the importance of knowledge, developing critical, creative, and innovative thinking skills, leadership skills, proficiency in Bahasa Malaysia and English language, character and values and a strong sense of national identity. These elements also highlight the focus on enabling students to contribute meaningfully to their family, society and the nation. Students need to master a range of important cognitive skills, for instance: creative thinking and innovation, critical thinking and reasoning, learning capacity. These skills can be developed by providing interesting and interactive classrooms through project-based and group work. The pedagogical approach will emphasize the use of project-based activities and questioning techniques to develop students; capacity for higher-order thinking skills and to help students see the connection between different subjects.

Science education in early childhood education is actively used, the child's experience should be based on former theories; children need to ask their questions and tasks should raise curiosity and encourage them to produce their thoughts so that they can carefully observe the topic in an orderly manner. They are encouraged to reflect, represent, express their experience and share their opinions with others. These processes should include children's daily studies and enable them to access the science experience. At the end of the pre-school period, students should be able to understand science in a clearer and unimaginable word than



they think. They also recognize that it is impossible to make correct predictions about the entire object when only one side is seen. In line with this expectation, science education should encourage students through various activities to improve their scientific process skills at higher cognitive levels. The instinct of children motivates them to learn because learning new things is a natural characteristic of a child.

Environmental factors are essential for the development of children during the early years. Lack of adequate stimulation will result in the development of children not reaching full potential. Hence, science education should begin in the early years of schooling. Particular involvement with the development of quality science experience is crucial to help children to explore the world, gathering and organising information, applying and testing ideas, and developing positive attitudes towards science. The experience of a quality science learning provides a solid foundation for the development of concept science that will be faced by children throughout their academic life. This foundation can help students build an understanding of fundamental science concepts and enable future learning of more abstract ideas. Research on supporting science education in early childhood as they advance scientific thinking in early childhood can bring children easy to move their thinking skills to other academic domains that can support their academic achievement and their feelings (Trundle 2010).

The new curriculum emphasizes on the higher-order thinking skill such as analysing, critical thinking and inquiry-based learning, for instance, through the increased of use of laboratory work, student-directed inquiry and ICT games based instructional materials (Malaysia Education Blueprint 2013). Providing students with real-life projects can be instrumental in fostering and maintaining their interest in STEM. Being exposed to real projects and brainstorming society's current challenges provide students with a broader perspective related to the social-environment aspect of the application of the basic concepts they have learnt.

Importance of Project-based Learning

Project-based learning is a model for a classroom activity that shifts away from the usual classrooms practices of short, isolated, teacher-centred lessons. PBL learning activities are long-term, interdisciplinary, student-centred and integrated with real-world issues and practices. It is a method that fosters abstract, intellectual tasks to explore complex issues (Educational Technology Division 2006). It is defined as an innovative approach to learning that teaches a multitude of strategies critical for success in the 21st century.

It has been shown that PBL is more effective education methodology compared to traditional pedagogies to promote a collaborative learning environment that can, in turn, enhance students' social and problem-solving skills. In PBL, students explore, make judgements, interpret and synthesize information in meaningful ways (Bell 2010). Students drive their learning through inquiry, as well as work collaboratively to research and create projects that reflect their knowledge. PBL approach is based on scientific principles and emboldens students to discovery learnings, enhances metacognitive strategies about the quality of life, results in realistic products following the authentic questions and topics (İlhan 2014).

The projects carried out by students support them to improve their real-world skills such as research, scientific thinking, creative and critical thinking, hands-on skills, communication and presentation abilities by working in groups by their managerial skills. Students in small or big groups collaborate to reach collective outcomes over a period. They search solutions to a problem by posing and refining questions and discussing ideas, collecting and analysing data, drawing conclusions and presenting the findings to each other (Zimmerman 2010). Teachers will only be the facilitator in the learning process, supporting materials, increase motivation and bring in relevant educational experiences through crucial projects. Students are encouraged to interact socially with their teammates to share project ideas.

In project-based learning, learners pursue knowledge by asking questions that have piqued their natural curiosity. It is considered as a

student-driven, teacher-facilitated approach to learning as the provenance of a project is an inquiry. (Bell 2010). PBL helps students develop skills for living in a knowledge-based and highly technological society. The old-school model of passively learning facts and reciting them out of context is no longer sufficient to prepare students to survive in today's world.

During the process of project-based learning, children with similar inquiries may elect to work cooperatively, thereby nurturing the 21st-century collaboration and communication skills and honouring students' learning styles or preferences (Bell 2010). Solving highly complex problems requires students to have both fundamental skills and Digital Age skills. With this combination of skills, students become directors and managers of their learning, guided and mentored by a skilled teacher (Educational Technology Division 2006). Children solve real-world problems by designing their inquiries, planning their learning, organising their research, and implementing a multitude of learning strategies (Bell 2010).

In the study of İlhan (2014), an experimental study was carried out in social science students to develop students' conceptual achievement and motivation to succeed academically. The study aims to investigate the effectiveness of project-based learning in social science. The findings indicated a drastic improvement in favour of the students exposed to the project-based learning approach instead of the traditional classroom approach. Students who undergo the project-based learning approach for six weeks showed enrichment in their knowledge; they also achieved a higher level of motivation compared to the control group, which had not taught by using project-based learning.

In another research, the effect of project-based learning on students' learning outcomes in Transportation Engineering was studied. LITEE survey instrument was used to measure different aspects of student learning. The significant findings showed that the use of project-based approach significantly improved students' ease of learning the subject matter (Hamoush S. et al. 2011).

Similarly, Sahin et al. (2015) investigated a new STEM project-based learning teaching approach that incorporated a full curriculum, including ready-to-teach teacher materials, PBL projects for all core subjects, regular teacher training and aligned with multiple state standards. Findings showed that apart from academic gains, students also showed enhancements in their social and emotional gains. Students started to feel that they could achieve such things as presenting to groups, communicating with other students and as well as making a connection with the things happening around them.

A study by Iwamoto et al. (2016) analysed the effectiveness of an alternative pedagogical approach in the form of a standards-focused project-based learning teaching model in psychology classes. Results showed that the experimental group scored significantly higher in the multiple-choice exam. No significance was found in the second experimental group where the majority of the students did their part; however, they did not report feeling a sense of responsibility for the learning of their peers.

On the other hand, in the research of Özer & Özkan (2012), the effect of project-based learning on the science process skills of prospective teachers was studied. Two assessment were used: Science Process Skills Assessment Instrument and Project Presentations Assessment Instrument Chart. The significant findings showed that grading from science process skills of making an observation, designing experiments and deductions of the experimental group were much higher. However, the standard deviation grades were lower in the science process skills of making an observation, designing experiments, assessment, numerical and spatial association recording data and deduction. It was concluded that the project-based learning method was effective in those process skills of the experimental group.

Project-based learning is holistic and incorporates the principles of providing challenging and complex work, interdisciplinary and encourages cooperatives learning. PBL helps to build on individual strengths and allows individuals to explore their interests in the framework of a defined curriculum. Project-based learning lends



authenticity to learning. While in practice, practitioners plan, implement and evaluate projects in real-world situations beyond the classrooms. It promotes understanding, which is true knowledge (Educational Technology Division 2006). The milestone of project-based learning is the creation of learners-centred learning environment to develop the motivation to succeed academically, and one of the most important purposes of this learning approach is to increase students' intrinsic motivation.

Discussion and Conclusion

Scientists are high-tech workers who know to turn the wheel of the global economy. Several projects and programmes have been launched to prepare the next generation's scientists. Statistics, however, showed a disproportionate growth in terms of numbers and quality of the science students. Hence, developing a quality science education is crucial to equip students for the 21st century for the country's economic wellbeing. The traditional way of teaching and learning is not sufficient to gear students to participate in the community actively or even survive in the real world. The ministry of education has suggested several approaches and programmes in order to equip students towards 21st-century skill. The 21st-century teaching and learning require students to develop a high-level cognitive skill. Thus, different authentic and innovative instruction methods in teaching should be adopted to create more interesting and interactive lessons in science.

In dealing with the challenges of the 21st century, students should no longer be assessed based on academic grades only, but they also need to master 21st-century skills which encompass problem-solving skills, critical and innovative thinking and the ability to work as a team. One of the learner-centred approaches is project-based learning, which has been highly recommended in education reforms (İlhan 2014). PBL is project centred and oriented, student-centred and focus are more on the learning process in finding a solution. Project-based learning is a basic method used to ease students in acquiring the necessary knowledge, vital skills and values required for the 21st century. PBL tries to cultivate students' ability to think critically, to learn actively and to solve problems through project-based activities. It also develops communication skills as students have to conduct group discussions (Wan Husin et al. 2016).

Implementation of PBL in STEM outlined in Malaysia Blueprint 2013-2025 would provide excellent opportunities for students to be engaged in self-directed learning and to enhance their soft skills. In line with the objective of STEM education to develop inter-disciplinary thinking, the PBL approach is one of the methods that are suitable in STEM education. STEM is based on project-based learning, and it incorporates the development of students' skills and also encourages creativity and hence is seen as an approach that has potential in creating students who would be able to learn better through meaningful teaching that is associated with real-life situations. Most importantly, the students would be able to experience the situation themselves. PBL is also an alternative teaching method where students are immersed in an environment which focuses on teaching through project work and not solely on oral teaching (Malaysia Education Blueprint 2013). Therefore, through by using the PBL approach, the teaching and learning processes in STEM-based education can achieve its objective of catering to the needs of the 21st-century generation. The learning experiences will gear students to build a strong foundation in STEM and to face challenges in their future career in this 21st century.

The PBL approach can elevate students' interest in science. PBL helps to develop students' sense of importance for science subjects by making it easy for students to learn science and therefore, increasing their interest in science. Furthermore, it is found that the project integrated into PBL gave hands-on experience to students in solving sustainability-related problems not only in terms of particular technical aspects but the ability to identify the economic and social aspects of the problems. Since students' achievement is an important issue in education specifically in the Malaysian context, the PBL approach is relevant as the approach can elevate students' achievement and highly

motivate them to participate actively in their learning processes (Yusoff et al. 2011).

Project-based learning is used in science subjects as it is relevant and exciting for the students by giving them opportunities to become independent learners. When every student is given a chance to make their contribution to the project in the field of their expertise, the class can benefit from such diversity. This opportunity might have an invaluable impact on students' content knowledge, as well as on their self-confidence and self-efficacy toward sciences. PBL is based on the ideas of social constructivism, emphasizing the role of the social environment in teaching and learning, promoting mutual respect, support and understanding, making an impact on student-student and student-instructor relationships. Project-based learning in science includes a context that engages students in extended authentic investigations through a driving question, collaborative work that allows students to communicate their ideas, learning technologies to find and communicate solutions, and the creation of artefacts that demonstrate student's understanding. A driving question links concepts and principles and drives activities and investigations throughout a project. Projects aid to extend students' learning experiences beyond the classroom by posing driving questions that situate the science with issues that are likely to be of interest to scientists, community-based organisations, and families, helping the learners to relate the new ideas explored in the project (Kubiato & Vaculová 2011).

In conclusion, the 21st-century core skills identified as critical thinking, creativity, communication and collaboration and project-based learning supports the development of individuals in the 4 areas. Project-based learning helps to provide an effective way for both teachers and students in order to establish a creative and supportive learning environment. Project-based learning is said to aid students to study cooperatively, acquire a deeper understanding and to improve their interest and abilities (Kubiato & Vaculová 2011). Hence, a study on project-based learning in science should be conducted to increase the engagement of students and lead to better education outcomes, especially in science subjects. Students flourish under this student-driven, motivating approach to learn and gain valuable skills that will build a strong foundation for their future in our global economy.

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