# Fostering students' 21st century skills through Project Oriented Problem Based Learning (POPBL) in integrated STEM education program

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## Abstract

Students nowadays need to be equipped with twenty first century skills in order to ensure their competitiveness in this era of globalization, especially in the science and technology sector. Therefore, this study aimed to identify the changes of 21st century skills among students after participating in an integrated Science, Technology, Engineering and Mathematics (STEM) education program. Project Oriented

Problem Based Learning (POPBL) approach was applied in the learning activities of this program as its fundamental pedagogy. A total of 125 secondary school students of the age 13-14 namely from the rural areas were involved as respondents. This study employed one group quasi-experimental to identify the students' 21st century skills before and after participating in the program. Data were analysed for descriptively, followed by an inferential analysis to compare the means (t-test) between the pre and post test. The findings from this study revealed that the level of 21st century skills (Digital age literacy, Inventive thinking, Effective communication and Spiritual values) among the students did increase and the increase was statistically significant. Interestingly, one of the components of the 21st century skills, namely 'high productivity skills' showed positive changes, from moderate to high level skills. The outcome of this study provides evidence that the application of POPBL in STEM education programs could help students to enhance their 21st century skills by learning how to solve real world problems based on authentic and real life experiences through project work.

**Keywords**: 21st century skills, POPBL, Integrated STEM education, Project based learning, Problem based learning, Digital age literacy, Inventive thinking, Effective communication, High productivity, Spiritual values

# Introduction

Education plays a crucial role in ensuring future generations are able and well-equipped to face the challenges of the 21st century. Across the globe, educationists have realised that children require more than just the 3 R skills (Reading, wRiting & aRithmetic) when they leave school. This is because in the globalised 21st century, the need to create high-quality human capital is more important than ever (MOE, 2012b). Therefore, in order to compete in the global marketplace, Malaysia needs to produce new workforce that is not only able to use technology, but also capable of contributing to the technology. In other words, a workforce that is able to innovate, invent and solve problems.

### 21st century skills

The most important asset to achieve a high-income developed nation status is quality human resource that can face the challenges of applying 21st century skills. To spur a world class nation, human resource which is competitive, knowledgeable, creative, and possesses positive ethics plays an important role. The North Central Regional Educational Laboratory and Metiri Group have created a 21st century education model which is known as enGauge 21st Century Skills (NCREL & Metiri Group, 2003). 21st Century Skills is a new set of skills which is needed to prepare students to survive and work in the digital era. With this model, there are four main criteria which need to be weighed to produce a generation which is capable of handling 21st century challenges. The four criteria are Digital age literacy, Inventive thinking, Effective communication and High productivity. Additionally, to accommodate the unique Malaysian context, another criteria that is spiritual norms and values has been added (Osman & Marimuthu, 2010). In this research, all five criteria of the 21st century skills have been examined.

The first 21st century skill is Digital age literacy which encompasses communication competency, analysing and interpretation of data, understanding and assessment of models, task management and task prioritization, involvement in problem solving, and ensuring wellbeing and safety (Kay & Honey, 2005). Digital age literacy needs to be developed in a student to ensure that the student is able to maximize technology usage in 21st century learning. The second skill is Inventive thinking. Inventive thinking is a cognitive activity which supports application of creative thinking in a creative and critical manner with skills in problem solving through innovative or specifically designed activities. NCREL and Metiri Group, (2003) as well as the Committee Workforce Needs in Information Technology (2001) have defined a few elements or 'life skills' in inventive thought ability, and these are adapting and managing complexities, self-regulation, curiosity, willingness to take risks and high level thinking. The third skill is Effective communication. Effective communication is a skill which needs to be developed by each individual in this 21st century. It encompasses information delivery, teamwork, interpersonal skills, social responsibilities, interactive communication and communication towards the environment (NCREL & Group, 2003). The learning process becomes much more exciting and valuable when communication activities use ICT as a medium to obtain information, to communicate faster, and as a supporting medium which assists in the learning process. The fourth skill is High productivity. According to NCREL and Metiri Group (2003), high productivity is defined as the ability of a student to adeptly produce products that are relevant, high in quality, intellectual, of current information and original. Additionally, high productivity skilled-student is also competent in delegating and structuring tasks in terms of importance and priority, and skilled in planning and producing high quality products. The final skill is employing Spiritual values whereby this skill emphasizes the practice of religious knowledge and beliefs, positive attitude and moral values.

## POPBL and STEM Integrated Program

In dealing with the challenges of the 21st century, the work sector requires workers who possess marketability value which encompasses problem solving skills, critical and innovative thinking and the ability to work in a team. To achieve that, students can no longer be assessed based on academic achievements only, but they also need to master 21st century skills. There are many student-centred teaching and learning approaches and processes and POPBL is one of them. The POPBL approach is a teaching method in the pedagogy model which was first used in Problem Based Learning (PBL) (Uziak et al., 2010). POPBL is project centred and oriented. The basic principles of POPBL can be summarized as (i) student-centred and able to motivate and increase commitment among students; (ii) focus is more on learning process in finding solution; (iii) project-based which has goal and action for change; (iv) having exemplarity; and (v) promotes group work/team work, social and communication skills (Yasin & Rahman, 2011). POPBL 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. Implementation of POPBL in STEM Programs therefore would provide great 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 (Wells, 2008), the POPBL approach is one of the methods that is suitable in STEM education. POPBL 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, and most importantly the students would be able to experience the situation themselves. POPBL 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 (Mohamed et al., 2012). POPBL incorporates the development of students' personal skills and also encourages creativity (Ibrahim & Halim, 2013). Therefore, it is hoped that through POPBL, the teaching and learning processes in STEM-based education can achieve its objective of catering to the needs of the 21st century generation. This is because in POPBL students begin with analysing the research problems and followed by designing the projects to solve the problems. (Yasin & Rahman, 2011, Yasin et al, 2012). This learning experiences prepare students to have a strong foundation in STEM and to face challenges in their career and to go through life in this 21st century (Jones-Kavalier & Flannigan, 2008). Additionally, since nature of the STEM Programs is project oriented therefore the role of the instructors is more towards being a facilitator, and according to Shamsudin (2007), in PBL, facilitation techniques are open and flexible thus effective in creating a better learning environment.

Maria (2008) and Yusoff et al., (2011) in their research with Malaysian students suggest that the POPBL approach can elevate students' interest in science. POPBL has the ability 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 (Maria, 2008). Furthermore, Yusoff et al. (2011) found that the project integrated in POPBL gave hands-on experience to the engineering 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 POPBL approach is relevant as the approach is able to elevate students' achievement and highly motivate them to participate actively in their learning processes (Ibrahim & Halim, 2013; Mohamed et al., 2012). Through teamwork, POPBL can promote human skills in the students through effective communication between the team members and planning (Ibrahim & Halim, 2013; Jensen et al., 2003). Mohamed et al. (2012) in their studies on the application of POPBL among engineering undergraduate students found that teaching and learning processes which employ the POPBL approach were able to increase students' ability to analyse and create analogue circuits using various types of transistors and diodes.

## Context of the study

In Malaysia, the objectives of Science education are to develop human resource that is competitive and resilient at the global level, capable of becoming a contributor to the development of science and technology, and capable of mastering scientific knowledge and technological craftsmanship (MOE, 2011). Even so, the decline in students' interest, especially towards science in Malaysia (Osman et al., 2007; Iksan et al., 2006), is going to be a challenge in achieving that objective. The average score for Malaysian students in the Trends in International Mathematics and Sciences Study (TIMSS) examination clearly indicates a downward trend whereby Malaysian students' average score went down from 510 in 2003 to 471 in 2007 and 426 in 2011 (IEA, 2008, 2012; MOE, 2012c).

PISA (2009) results indicated that Malaysia was ranked at the bottom three out of 74 participating countries and was also below the international and OECD average. In 2011, only 45% of student graduates were from the Science stream, including technical and vocational programs (MOE, 2012a). This scenario cannot be ignored because it will affect Malaysia's efforts in achieving developed nation status in 2020 where Malaysia needs 33% of workforce in the field of science and technology. Steps need to be taken to achieve the targeted number of graduates in STEM-related fields to increase the number of future workforce capable of working in the science and technology sector.

In line with the country's aspirations, programs that incorporate the various disciplines of science such as Science, Technology, Engineering and Mathematics (STEM) which are conducted outside of schooling hours are seen as an alternative that could positively affect the efforts to increase interest and involvement in STEM and at the same time, increase the level of 21st century skills among students. According to Shahali et al. (2015), STEM learning experiences prepare students for the global economy of the 21st century. In addition, the integration of these STEM subjects will spur the minds of students to be creative, critical, and innovative, and this in turn contributes to the advancement of technology. English and King (2015) argue that the concept of integration in STEM Education can help students to become better problem solvers, display more positive and motivated learning, and improve in their mathematics and science achievements. According to Becker and Park (2011), STEM education is an approach that explores the processes of teaching and learning between any two or more STEM components or, between any one STEM components with another field of knowledge. The Malaysian education system is already equipped with science, mathematics and engineering which are taught as a stand-alone subject, but the integration of science and mathematics with engineering concepts can be a better practice as compared to the traditional method. In fact, STEM education is the integration of technology and engineering design concepts in the teaching and learning processes of science and mathematics (Sanders, 2012). The Education Ministry (MOE) in the Blueprint (MOE, 2012a) has clearly stated that they will strengthen the delivery of STEM across all education systems.

STEM is meant to transform traditional classrooms from teacher-centred instruction into inquiry-based, problem solving, discovery zones where children engage with content to find solutions to problems (Fioriello, 2010).

## Conceptual Framework

The POPBL in STEM education program in this research, also known as *BITARA* STEM program, aimed at increasing students' participation in the fields of Science, Technology, Engineering and Mathematics (STEM), and eventually enabling the students to compete in this 21st century. The approach of this program is based on multi-disciplinary features, active learning through inquiry, application of 21st century skills, and exposure of students to careers in the fields of contemporary science and technology. The learning theories underlying this research are the theories of Constructivism and Constructionism. The Constructivist theory comprises of five phases, namely the orientation phase, idea generation phase, idea restructuring phase, idea application phase, and reviewing phase. The Constructionist theory is applied during the idea application phase, throughout the processes of practical activities which involve real world problem solving in the *BITARA* STEM Module. According to the Constructionist theory, the generation of new ideas will happen effectively if participants are involved in artefact designing processes (Papert, 1991). This theory emphasizes participants' involvement in artefact designing activities in the learning process (Kafai & Resnick, 1996).

Figure 1 shows the POPBL which is the main approach in this STEM Integrated Program. It consists of five steps, namely Real Problem, Group Discussion, Data Collecting & Analysing, Communicating, and Constructing New Product. This framework combines the concept of science, technology, mathematics and engineering which is adapted from engineering design process, namely the *Think, Make, Improve* (TMI) model (Martinez & Stager, 2013). According to English and King (2015), engineering design can advance students' abilities and dispositions to solve complex, real-world problems. This engineering design process is applied by participants in their artefact designing process through three main stages, namely, *Think*, *Make*, and *Improve*. During the *Think* stage, after participants have been given a situation or real world problem to solve, they will discuss and work in a group to identify the problem, give suggestions, and make plans. The facilitators will continue to support each participant to ensure they complete this stage effectively. At this *Think* stage, students are applying the first and second step in POPBL which is analysing the real problem and group discussion. During the *Make* stage, participants build, create, experiment, solve the issue, and any other issues arising during artefact design. After the artefact has been completed, testing is conducted to identify any problems that arise. At this stage, they are applying the other two steps in POPBL which are data collecting & analysing, and constructing new product. Finally, at the *Improve* stage, participants will improve the artefact that they have built by testing and rebuilding the artefact again with improvements to identify arising problems, or build a much better artefact following the guidelines which have been set. While working through all these stages, students will always be communicating with each other. In addition, the discussion and the presentation of their artefact will also improve their communication skills.

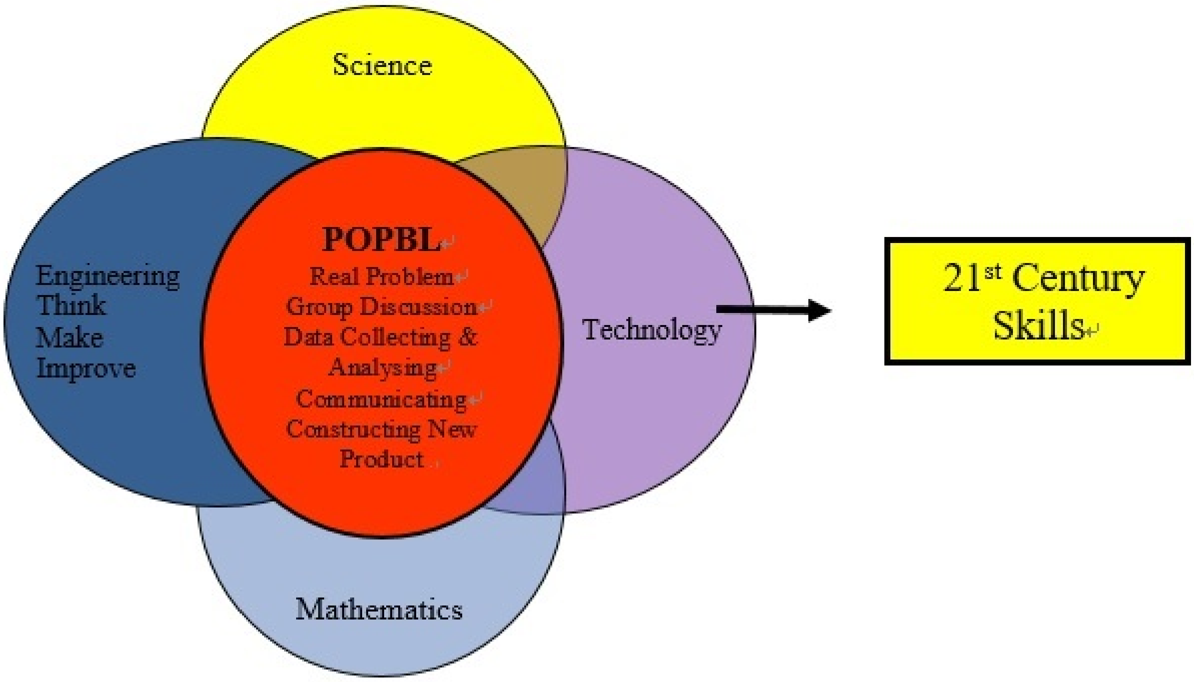


**Figure 1**: Conceptual Framework of *BITARA* -STEM Program

## Objective and research questions of study

The objective of this study was to assess the effect of POPBL in STEM education program on students' 21st century skills namely Digital age literacy, Inventive thinking, Effective communication, High productivity and Spiritual values.

The research questions were

1. What is the level of 21st century skills of the students before they were involved in the POPBL in STEM education program?
2. What is the level of 21st century skills of the students after they were involved in the POPBL in STEM education program?
3. Was there any significant changes to level of 21st century skills of the students before and after the STEM education program?

# Methodology

## BITARA-STEM Program

Learning by doing is a way to help students to understand and gain meaningful learning especially the abstract content effectively. One of the methods to promote learning by doing is called POPBL. Students learn how to solve real world problems based on authentic and real life experiences through project work that emphasizes the creation of artefacts. The success of the project work comes from the collaboration between students by working in teams while the teacher acts as the facilitator. Designing POPBL approach with integrated STEM is still new in the learning environment. In this study, a program called '*BITARA*-STEM Program' was conducted for six days. This program implemented POPBL in the STEM education program. The learning activities in this program were project-based. They consisted of multi-disciplinary activities that provided students with fun learning that are based on student-centred approach. Implementation of POPBL with integrated STEM in this program was carried out in order to develop 21st century skills, higher-order thinking and research skills among the students. Four separate units of modules were introduced to the students for them to participate in, namely (i) Energy, (ii) Urban infrastructure, (iii) Transportation, and (iv) Wireless communication (Table 1).

**Table 1.** Units of intervention and activities

| Unit | Modules | Example of Activities |
|---|---|---|
| Energy | • Introduction to Newton's Law &Electrical Basics<br>• Worldly environment<br>• Power generation<br>• Power storage<br>• Biomimicry | • Balloon rocket & parachute.<br>• Rain in the bottle<br>• Potato battery<br>• Hydrogen fuel cell<br>• Fish tail |
| Transportation | • Modes of transport | • Make a circuit |

| | | |
|---|---|---|
| | • Smart transportation<br>• Smart highways<br>• Intelligent transportation systems<br>• Traffic engineering | • Robot programming |
| Wireless Communication | • Smart electronics basics<br>• Real time communication<br>• Space based wireless communication<br>• Internet and communication network<br>• Smart wireless communication | • Flash LED<br>• Cell antenna |
| Urban Infrastructure | • Environmental engineering<br>• Soil and land development<br>• Building towards the future<br>• Recycling and waste management<br>• Natural disasters | • Pump It!<br>• Water turbine<br>• Earthquake Town |

This study employs the pre-test post-test quasi experimental design. We realized the limitations of this method. However, as an exploratory study, one pre- post test approached is deemed acceptable.

## Respondents

The respondents in this study comprised of 125 lower secondary school students (age 13-14 years old). The majority of the participants obtained excellent results in the national examination for Standard Six (12 years old) also known as the Primary School Evaluation Test (UPSR), where 60.7% and 77.9% of the participants scored 'A' for science and mathematics subject, respectively.

## Instrument and Procedure

The instrument used in this research is a set of questionnaire which employed the Likert Scale with five degrees of agreement (1=strongly disagree to 5=strongly agree) in measuring students' perception of their 21st century skills. The instrument used was adapted from Arsad (2011) which takes into consideration the skill components from enGauge 21st century skills, namely (i) Digital age literacy, (ii) Inventive thinking, (iii) Effective communication, and (iv) High productivity, with the additional component of Spiritual values which is a component that is adapted to suit the Malaysian Education Philosophy. This instrument has been checked and verified by experts (construct validation, content and language). The instrument has acceptable and good credibility (George & Mallery, 2003) with all constructs achieving a high Cronbach Alpha value of between 0.78-0.86 in the pilot study (Table 2).

**Table 2.** The Cronbach Alpha Value for 21st century skill elements and Example of Items

| Element | Cronbach Alpha | Item | Number of items |
|---|---|---|---|
| Digital age literacy | 0.83 | • I can understand the concept of science and mathematics that the teacher teaches in English.<br>• I am able to evaluate the information regarding science. | 7 |
| Inventive thinking | 0.77 | • I can be positive towards the problem with level of difficulty that is beyond my expectation.<br>• I am interested to find out new and unusual things that I can find from the surrounding | 12 |
| Effective communication | 0.81 | • I act as a leader and follower at the same time in completing the assignment.<br>• I collaborate with team members in any circumstances. | 8 |
| High productivity | 0.74 | • I plan the time provided to complete each assignment.<br>• I create product from my project or practical science. | 8 |
| Spiritual values | 0.85 | • I am thankful because I am able to learn science and mathematics.<br>• I always associate the science knowledge needed in the world or the hereafter. | 5 |

Participants of the program answered the questionnaire before and after the experiencing the *BITARA* STEM program.

*Analysis*

Mean scores for each aspect of the 21st century skills investigated were determined. Paired sample t- test was used to identify the differences of mean scores between pre and post tests. In addition, the mean scores were divided into three categories. The categories were i) low level – mean score 1.00 to 2.33; ii) moderate level – mean score 2.34 to 3.67 and iii) high level – mean score 3.68 to 5.00 (William, 2003).

## Results and discussion

Table 3 shows the mean score and the standard deviation (SD) values from both the pre- and post-tests for the five constructs of 21st century skills investigated. Table 3 indicates that the initial level of students' skills in all five aspects of 21st century skill is relatively high, with mean scores between 3.77 to 4.55. This high perception of their skills is probably due to the fact the respondents are high achievers as demonstrated in their performance in UPSR. High achievers tend to demonstrate also high self-esteem and interest in their performance (Aryana, 2010; Ulrich, 2010). The mean scores of each aspect of investigated 21st. century skills are also high after the students undergone the STEM education program.

Findings from the pre- and post-tests were used to study the effects of POPBL approach in STEM programs on 21st century skills. The mean score from the pre-tests were compared with the mean score from the post-tests using a paired sample t-test. 21st century skills were tested in five aspects, which were (i) Digital age literacy, (ii) Inventive thinking (iii) Effective communication, (iv) High productivity, and the added component, (v) Spiritual values.

**Table 3.** T test results of students' 21st century skills' mean score

| Skill | Test | Mean | Std. Deviation | t-value | Sig (2- tailed) |
|---|---|---|---|---|---|
| Digital age literacy | Pre-test | 3.774 | 0.419 | 3.424 | 0.001* |
| | Post-test | 3.916 | 0.498 | | |
| Inventive thinking | Pre-test | 4.015 | 0.412 | 1.377 | 0.171 |
| | Post-test | 4.082 | 0.601 | | |
| Effective communication | Pre-test | 4.088 | 0.426 | 1.942 | 0.055 |
| | Post-test | 4.173 | 0.598 | | |
| High productivity | Pre-test | 3.851 | 0.401 | 5.878 | 0.000* |
| | Post-test | 4.121 | 0.481 | | |
| Spiritual values | Pre-test | 4.550 | 0.414 | 0.994 | 0.322 |
| | Post-test | 4.511 | 0.525 | | |
| 21st century skills | Pre-test | 4.055 | 0.331 | 2.996 | 0.003* |
| | Post-test | 4.145 | 0.451 | | |

*significant < 0.05

Based on Table 3, it can be seen that there is a rise in the mean score values for all aspects of 21st century skills except for *Spiritual values* aspect, which shows a decrease in mean score but there was no significance difference between groups. As a whole, the findings show that there is an increase in mean score for 21st century skills after students have undergone the *BITARA* STEM program with a t value of (125)=2.996. The findings also show that there is a significant difference for the aspect *Digital age literacy* with a t value of (125) =3.424 and *High productivity* with a t value of (125) =5.878. However, there are two aspects of 21st century skills which do not show any significant difference, namely *Inventive Thinking* with a t value of (125)=1.377 and *Effective communication* with a t value of (125)=1.942. As a whole, the level of 21st century skills for the majority of students is at a high level. After attending this program, the percentage of students who exhibited a high level of 21st century skills increased by 4.9%. Figure 4 shows the analysis of the findings on the percentage of students according to stages of 21st century skills exhibited, in which the 21st century skills that the students demonstrated have been divided into 3 stages, namely low, medium and high.

**Table 4.** Percentage of students according to stages of 21st century skills

| **21st century skills** | | **Low** | **Medium** | **High** |
|---|---|---|---|---|
| Percentage (%) | Pre-test | 0 | 11.5 | 88.5 |
| | Post-test | 0 | 6.6 | 93.4 |

There are a few important 21st century skills which have to be mastered by students. Through the analysis which has been conducted, it was found that the level of 21st century skills showed an increase in every skill after students attended the *BITARA* STEM Program with the exception of *Spiritual Values.* The highest increase occurred for *High Productivity* with a difference in the mean score between the pre- and post-tests attaining a value of 0.27, followed by *Digital Age Literacy* (0.142), *21st Century Skills* (0.09), *Effective communication* (0.085), and *Inventive Thinking* (0.067). It appears that the integration ofPOPBL and on STEM education has helped the students to develop further 21st century skills. POPBL provides opportunities for students to apply their knowledge, and simultaneously encourages them to gather information. Similarly, the characteristics of POPBL that promote group discussions encourage students to carry out collaborative learning which allows students to choose the most efficient way to solve the task using their existing knowledge as well as new knowledge. This can help to improve students' concentration and boost learning, enhancing their creative skills and enabling them to develop positively into the 21st century.

In the *BITARA* STEM Program, the teaching and learning approach emphasized upon was the usage of POPBL methods where various *hands on-minds on* activities were applied, starting with problem identification and ending with a solution to the said problem. Research findings show that the teaching and learning activities in the *BITARA* STEM Program increased the students' level of inventive thought even though the increment is insignificant. One possible reason is that through the activities carried out in small groups, the students had to work and think together on how to solve the problems that they faced by applying their individual experiences To achieve that, students had to explore and make connections between the problem's situation and the situations that they have experienced themselves in real life. Thus the learning situation that is applied in the *BITARA* STEM Program can encourage students to become innovative and creative in their invention. In order to produce high quality product, students must be able to distribute task according to their importance. This shows that the student have systematic planning skills.

In addition, the students were also required to design new artefacts. Artefact design which was formed based on ideas shared with other team members managed to increase the students' inventiveness and this had a positive effect on *High Productivity*. This finding is in line with research by Ibrahim and Halim (2013), and Mohamed et al. (2012) where it was found that POPBL can enable students to achieve high results in their work.

The curriculum for the 21st century should be relevant and coherent with the current situation. The design of the curriculum of the 21st century needs to be futuristic, flexible and dynamic so that creative and innovative human capital can be generated. Therefore, in addition to providing students with skills to collaborate with others, skills of the 21st century require students to work together and communicate through technology. The findings of this research also revealed that students possess *Digital Era Literacy Skill* which was elevated after attending the *BITARA* STEM Program.

Technology literacy is a skill that gives a big impact to master the digital era literacy skill (Arsad et al., 2012), through the usage of technological equipment for example the used of internet during the teaching and learning process enable students to find additional information The latest technology like robotic programmer in Wireless

Module provides this new experiences to the students. However, there is decrease in the mean score for *Spiritual Values* (-0.039) after students attended the *BITARA* STEM Program and this phenomena requires further research. This finding on *Spiritual Values* calls for improvement in terms of the application of spiritual values during the teaching and learning process to ensure that students are not only inventive, able to communicate effectively, possess digital era literacy skills and high productivity levels, but also equipped with spiritual values in order to develop a nation that is morally upright, whole and well-balanced.

Further analysis of the data on the percentage of students based on the level/stage of 21st century skills that the students exhibited revealed that none of the students were in the lowest level before and after taking part in the program. The post test demonstrated that the percentage of students having or exhibiting high level of 21st century skills increased after the students attended the *BITARA* STEM Program, an increase of 4.9% from the percentage score of the pre-test. This suggests that applying POPBL in the teaching and learning process of the *BITARA* STEM Program is able to capture students' interests and active involvement in the teaching and learning process, and ultimately increase the quality of students' mastery in STEM-based education. Research findings also show that the implementation of POPBL through STEM programs has managed to enhance the level of 21st century skills as perceived the students. By mastering 21st century learning skills, these students will be able to plan and make wise decisions for their future and address the challenges of globalization. Overall, through exposure to POPBL teaching and learning process, these students will be equipped with relevant learning and innovation skills, information skills, media and technology skills and also life and career skills that are necessary to survive in the globalised era of the 21st century.

## Conclusion

Based on the research findings, it can be concluded that the application of the POPBL approach in the teaching and learning process as implemented in the *BITARA* STEM Program may increase the students' level for the five elements of the 21st century skills, namely Digital Age Literacy, Inventive Thinking, Effective Communication, High Productivity and Spiritual Value. One is aware of that the study only employs a one pre and post test group and the skills exhibited by the students were more on perception based. Nevertheless, the findings provide as indicators to the possibility of POPBL when integrated in STEM education is able to foster 21st century skills in the STEM context. Future studies would involve a control group in addition to the experimental group. Measurement of the 21st century skills should be performance based. Also, a more qualitative study investigating the interactions during the program can illuminate the reasons for any enhancement or otherwise.

Meanwhile, POPBL as a collaborative teaching strategy can and has been shown to effectively increase communication skills- which is necessary for developing 21st century skills. Students' ability to link ideas of science and mathematics and apply technology and engineering design can be observed during the group discussion activities. This, therefore, demonstrates that POPBL and STEM Education programs should be promoted and carried out in schools. The implementation of project oriented and group activities can help nurture positive attitudes and interpersonal skills, such as teamwork, diligence, perseverance and creative thinking as well as presentation skills. It is important that the teaching and learning process in the classroom is relevant and coherent with the current situation. Therefore, pedagogic approaches and teaching principles such as this are much needed in today's teaching situation to produce students who are active, innovative and creative as they could help to prepare students for the challenges of the 21st century. One immediate implications of this study is to provide professional development course on POPBL with the teachers. Such an innovative teaching method requires understanding and abilities in order for effective implementation.

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