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IMPACT STUDIES OF INTEGRATED STEM PROGRAM

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Abstract— **Low student achievement in science and mathematics makes integrated STEM education essential. The integrated STEM program is an initiative to increase student interest in science. The program is interdisciplinary and multidisciplinary based, involves hands-on activities, experiments and demonstrations. A series of programs have been implemented by the National University of Malaysia called Bitara STEM and have positive effects in terms of students' interest in STEM and STEM career. The aim of this paper is to share the concept and program impact studies carried out. Students showed high interest in STEM subjects and STEM career after attending the integrated STEM program.**

I. INTRODUCTION

Incorporating STEM in School Science Education in formal learning or informal learning is necessary and crucial. STEM is a curriculum based on the idea of educating students in four specific disciplines - science, technology, engineering and mathematics in an interdisciplinary and applied approach. Rather than teach the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications.

STEM education is something that is authentic context-based approach that puts issues of personal, social and global "in the center position and use the four (4) STEM disciplines to understand and deal with these issues" (Bybee, 2010).

Rational for STEM education program is derived from concerns about several cases; competitiveness in the global economy, the impact of no child left behind (no children left behind) that causes a need to emphasize basic skills in science and mathematics education, the lack of preparation by students STEM cause low test scores on the national and international level and the wide gap in achievement among urban than in rural areas is significant.

Low interest in STEM field leads to low enrollment of students in science. STEM emphasis on basic skills in schools is vital in order to provide qualified students pursuing higher education in higher institution. Lack of STEM graduates in higher education has implications for labor supply shortages in engineering and other fields related to science and technology and eventually unfavorable implications for the economy. When viewed from an investment prospective, this may reduce the confidence of investors who rely on local scientists and engineers which can simultaneously inhibit Malaysia's vision to become a developed and high-income countries by 2020.

The Ministry of Education in Malaysia target for the ratio of 60:40 percent of students taking up science vs arts still has not been reached. The current status of enrollment in upper secondary school in 2013 showed that 29.2% of students were in the natural sciences, 1.3% and 4.5% of the technical vocational stream. The indirect supply of students to pursue science and technology at the tertiary level also decreases the target of labor in the field of Science & Technology is still much to be achieved as a benchmark of a developed nation by 2020. The lack of students choosing science is because students are afraid to embrace science as well as loss of interest due to teaching that emphasizes memorization, and views are not relevant to the current situation as well as career prospects are clearly detailed. Limited time and speed of the syllabus needs to be spent limiting opportunities for students to conduct experiments or scientific research through exploratory methods in the normal time schedule at school.

A. Problem Statement

Implementing the STEM approach is very difficult in this country because lots of teachers are tied to various aspects such as the syllabus of science and skeptical attitude of teachers towards informal education and less clear of STEM understanding by curriculum developers. Many consider that the activities implemented in schools have reached the STEM purpose. But this notion is far off the mark as the projects undertaken without planning and implementation of STEM approach that do not integrate STEM components could only see the processes and procedures of the project and not the STEM education. This makes the conventional understanding of learning and teachings of science in schools are not attractive and meet an impasse to increase students' interest in science. Through the STEM program, students seem to be very excited and focused when doing activities. Students are so eager and diligent when something is learned can be practiced.

B. STEM Education Abroad

A study by Freeman et al. (2011) deals with learning active learning than traditional lectures were conducted. The findings show that improving student achievement through tests and

inventories increased by 0:47 STEM concepts SD under active study (n = 158 study), and the failure rate was 1.95 under traditional learning lecture (n = 67 studies). These results indicate that the average test score increased by about 6% in active learning than students in traditional classroom lectures and students are 1.5 times more likely to fail than students in active learning class. Diversity analysis showed all STEM disciplines through active learning show more balanced inventory concept of the exam, and that active learning is an effective matching of all size classes - although the impact is greatest in small classes ($n \leq 50$)

Exploratory study by Duran et al. (2014) it assesses the impact of collaborative inquiry and design program after school programs (after school program) to students IT / STEM high school in the city to use information technology (IT) in the context of STEM. This study used a mixed method design, which involved two groups of 77 participants in the intervention cohort for eighteen months. Data collected before and after program participants analyzed in relation to IT projects, the report of the external evaluator, and interviews. The findings show that the program has a significant impact on the technology and IT skills / STEM students, the frequency of use of technology, and an understanding of using IT in the field of STEM-oriented. Little impact on changing attitudes towards IT / STEM and career aspirations in this field were also identified. This study shows that the experience of IT - STEM enrichment supported through technology and design strategies based on collaborative inquiry significantly impacted on student learning.

Blustein et al. (2013) studied the reaction of high school students in the city's program of strengthening and professional development of STEM careers, resources and obstacles, and their perspectives on the impact of race and gender on career development and their overall view of their future careers. The sample included nine students who took part in a semi-structured interview show that students continue to explore STEM fields after the summer program, reported an increase in STEM knowledge, described the strong identification with the identity of their race and gender, and identify resources and constraints relevant STEM-related education and career development.

C. Background of Bitara STEM Program

This Bitara STEM program initially is a joint collaboration between the National University of Malaysia (UKM), New York Academy of Sciences (NYAS) and New York University Polytechnic School of Engineering (NYU -Poly) aims to increase the participation of students in Science, Technology, Engineering and Mathematics (STEM) in order to compete in the 21st century economy. This STEM program is also an initiative under the Global Science and Innovation Advisory Council (GSIAC) chaired by the Prime Minister and it is one of the high-impact program GSIAC under Human Capacity Building agenda and initiatives Cradle to Career (C2C).

The pilot project of Bitara STEM program was carried out in 26-30 September 2013. A total of 89 school students aged 13-14 years and four teachers and 34 graduates of UKM involved. The 2nd pilot project was conducted in February 16 to March 1, 2014, a total of 90 students from 10 schools, 8 teachers and 35 UKM graduate students involved.

Bitara STEM then conducted an "outreach program" to children in in rural areas of the Federal Land Development Authority (FELDA) Trolak, Perak from 1 to 6 June 2014. The program involves 226 students from 10 schools in FELDA areas throughout Malaysia.

In 2015, the Bitara STEM program received the CLMV (Cambodia, Laos, Vietnam, Myanmar) Grant under the Higher Education Research Institute (IPPTN) and conducted a STEM Education Science of Smart Communities program. CLMV program was carried out in Cambodia in cooperation with Norton University (NU), Cambodia. A total of 20 students has been trained and the program is then carried out to 120 students at Maahad Al-Fickry Secondary School, Krochmar, Chumnik, in Kg. Cham, Cambodia on May 3 to 9, 2015.

Another program is the collaboration between UKM and ExxonMobil program called STEM Exploration Journey Camp on Sustainable Energy was implemented from 31st May to 4th June, 2015. Participants were 142 students from 10 schools and 62 facilitators of UKM postgraduates.

D. Research Questions

The aim of this study was to assess the impact on participants' interest of integrated STEM teaching by using a one group quasi-experimental design. The participants were pre- and post-tested on a range of variables and examine the outcomes for significant changes. This study was guided by the following research questions:

1. Are there any significant changes in the participants' interest in STEM subjects and STEM careers after attending Bitara STEM program?
2. Are there any significant differences between genders in the participants' interest and STEM career after attending the Bitara STEM program?

II. MATERIAL AND METHOD

A. Model of Bitara STEM Program

The model used for the STEM program involves three entities, namely; 1) Higher Education Institutions; 2) Undergraduate and Graduate Students; 3) Community (students, teachers, parents). The role of universities is to transform graduate programs, continuing the partnership, (School District, Industry), a greater effect on graduate

research and society. While also enhanced undergraduate and graduate research, the context of the community, communication skills, teamwork and leadership and teaching skills. The third entity and the most important in acculturation STEM are students, teachers and parents will be able to enhance the development of professionalism, content and pedagogy STEM enrichment, the enrichment of STEM learning, mentoring, more aware of STEM careers.

There are four (4) main module Bitara STEM learning activities undertaken throughout this program which is Energy, Urban Infrastructure, Transportation, and Wireless Network. Each module consists of five (5) units with several activities.

B. Conceptual Of Bitara STEM Integrated Module

STEM program was conducted for 5 days involving 3 phase process of delivering STEM activities of training (2 days), development projects (2 days) and exhibition (1 day). In the training phase the students were divided into four groups of modules. The approach used in increasing student interest and motivation in science and mathematics is a project-oriented. Students experience how to apply science and math through STEM projects. This project-oriented learning has been successful in creating an active learning environment where students are eager and earnest attempt to set up activities and projects assigned. It allows students to create, tests or experiments in the project.

Bitara STEM modules were developed using the concept of integrated STEM based on two learning theories which is of Constructivism (Piaget, 1977) and Constructionism (Papert, 1991). This module using constructivist learning theory emphasizes the construction of knowledge of students by establishing and actively structure their knowledge through their own learning experience. Before learning any knowledge or concept, usually students have had the initial idea (preconception ideas) and it came to be associated with knowledge or new concepts. However, sometimes the initial idea that different students had different scientific concepts or received and is known as the existence of alternative ideas or misconceptions. In order to change the alternative ideas or misconceptions, the proposed approach, as suggested by Piaget, through the cognitive conflict strategy.

According to Piaget, cognitive conflict occurs when a person's cognitive structures are in a state of unbalance (disequilibrium). It occurs when, new knowledge received is not equal to the structure cognitive owned. Thus, to overcome disequilibrium and reach a new equilibrium, modification of cognitive structures through the process of assimilation (using the existing scheme to receive new information) and the accommodation (existing scheme of individual change due to the reception of new knowledge) needs to be done in the learning process so that the individual can relate and integrate new knowledge with existing knowledge. In this Bitara STEM module, activities undertaken involve a lot of discussion and interaction with peers in groups and scaffolding by the facilitator. Therefore, iterations with a friend who did not experience the conflict as well as the guidance of a facilitator to assist the individual to get out of the conflict and helped change the terms of their conceptual through effective instruction and meaningful.

One model that supports the instruction to change the conceptual includes Needham five Phase model (1987). This model is used in the module for designing Bitara STEM teaching by teaching following the rules of constructivism. This model consists of five phases: orientation, arcing idea, restructuring the idea, application of ideas and reflection. In each phase, students will be provided with activities that help promote conceptual change through active learning process. They will build the meaning of the experiences provided in each module activities with the guidance of the facilitator.

In the application phase of this idea, the theory of constructionism applied during the process of practical activities that involve problem solving in real-world situations. Based on the theory of constructionism, the construction of new ideas happens effectively if the students involved in the production process of artifacts (Papert 1991). This theory emphasizes students' designed artifacts, activities in the learning process (Kafai & Resnick, 1996). The engineering design process of the TMI (Martinez & Stager 2013) model applied by the students in designing artifacts activities.

Model of TMI (Martinez & Stager 2013) consists of three main stages, namely Think (T), Make (M) and Improve (I). In the stage of Think, after a student were given the situation or to solve real problems, students will discuss and work collectively to identify the problem, provide feedback, and make plans. The facilitator will lead each group of students so that they can carry out this stage smoothly.

To enhance the effectiveness of the learning process and help students understand the relationship between theory and practice, contextual learning approach was applied in Bitara STEM Module. This approach applies indirectly during the application phase of the idea during the engineering design process implemented. This contextual learning approach involving REACT strategy of Relating, Experiencing, Applying, Cooperating, and Transferring.

After completion of the artifacts built, the next phase is the phase of reflection undertaken back in the final phase of the Needham Five Phases Model. The aim is to enable students are aware of the changes taking place and the idea that they can make a reflection on how far they have changed the original idea. Based on theory, approaches, models and strategies used, expected attitude and motivation toward STEM, can be enhanced through the use of this STEM module.

III. FINDINGS

A. Respondent Demography

The respondents consisted of 205 secondary school students. A full profile of the respondents is shown in Table 1

Table 1. Profile of survey respondents

Demography	Respondent	Frequency	Percentage
Gender	Male	83	40.5
	Female	122	59.5
	Total	**205**	**100.0**
School location	Urban Schools	58	28.3
	Rural Schools	147	71.7
	Total	**205**	**100.0**
Year	8	34	16.5
	9	169	82.5
	10	2	1.0
	Total	**205**	**100.0**

B. Impact on Program Effectiveness Vs STEM Students' Interest

Interest was examined from two aspects, namely the interest in careers in STEM and interest in STEM subjects. Table 2 shows a comparison of the percentage by stage, the mean, standard deviation and t-test for paired samples pre-test and post-test of the students' interest in careers in STEM and the interest of students to STEM subjects.

Table 2. Summary of percentage based on the level, mean, standard deviation and paired samples t test for the pre-test and post-test of the students' interest in STEM

Aspect		(%) Mean Score 1.00-2.33 (Low)	Mean Score 2.34-3.66 (Moderate)	Mean Score 3.67-5.00 (High)	Mean Score	Standard deviation	Level	Paired T-test t	Paired T-test p
Interest in STEM Career	Pre Test	0.8	4.8	94.4	4.305	0.405	High	1.346	.181
	Post Test	0.8	8.1	91.1	4.361	0.562	High		
Interest in STEM Subjects	Pre Test	0	8.9	91.1	4.192	0.462	High	1.349	.180
	Post Test	0.8	11.5	87.7	4.238	0.547	High		
Interest in STEM	Pre Test	0	7.3	92.7	4.247	0.385	High	1.621	.108
	Post Test	0.8	8.9	90.2	4.267	0.529	High		

From the findings, it was found that all aspects of students' interest in STEM registered high. In addition, there was an increase in terms of students' interest in the careers of STEM fields, students' interest and enthusiasm in STEM subjects after attending this program. This indicated that they have increased perception about careers in STEM and STEM subjects and wanted to get involved in STEM in the future, and motivated to study STEM subjects.

C. Impact on Student Interest according to Gender

The analysis found that female students showed an increase in mean scores were higher in all aspects of interest in STEM than male students. However, extensive testing using t-test independent samples revealed that significant value recorded by each aspect studied is significantly larger than the standard $p > 0.05$. It can be concluded that the differences increase students' interest in STEM among boys and girls is not statistically significant.

Table 3 shows the result of students' interest in STEM based on gender increased in the mean score.

Table 3. Mean scores of students' interest in STEM according by gender

Aspect	Gender	Mean Score	Standard deviation	T- Test t	T- Test p
Interest in STEM Career	Male	0.010	0.363	0.123	.347
	Female	0.089	0.529		
Interest in STEM Subjects	Male	0.046	0.347	0.122	.997
	Female	0.047	0.405		
Interest in STEM	Male	**0.026**	**0.318**	**0.123**	**.510**
	Female	**0.068**	**0.367**		

IV. CONCLUSION

Bitara STEM program impact study undertaken having a positive effect. The results of the tests before and after attending the program found that increasing students' interest in careers in STEM and STEM subjects, namely by 20%.

Results from the qualitative studied also showed that students were delighted with the assignment. Project of STEM has been successfully developing many talents of students such as leadership, creativity, innovation and other soft skills. Capabilities and abilities of students revealed when we allow these students to talk without interruption and teacher instruction.

Students are very active and aggressive for the completion of their STEM projects. Tasks distributed well, time is managed carefully, the resources that are given is well used and various positive measures being made to complete their projects. Here we can look at various aspects of science skills in addition to skills can be nurtured indirectly. Students also learn to manage crises that arise in the group and the risk taken in building their STEM projects.

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