Assessing the problem-solving skills among foundation level students: A STEM case study

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Abstract. The level of unemployment among fresh graduates in Malaysia is worrying with one in five graduates still jobless after six months of graduation. One of the reasons for this scenario as claimed by employers is the poor quality of graduates with regards to attitude and skills. STEM (Science, Technology, Engineering and Mathematics) education could help students by developing their problem-solving skills. The STEM module will encourage critical thinking skills, which is essential in troubleshooting a complicated scenario. This case study assessed the initial level of this vital skill at the beginning of the university study pipeline: the foundation-level. Four groups of students from different foundation programs in Universiti Selangor were selected for the assessment. It was revealed that 70 % students had the drive to work smartly until the problems were resolved. The rest of the students (30 %) responded that they will seek external sources to solve the problem if the problems were challenging to them. It was fascinating to note that 100 % students were committed to not quit until the problem was sorted out based on their responses. Completing STEM activities therefore, had enhanced the students’ creativity, increased their confidence level and improved their team work.

1. Introduction

An increasing trend in the unemployment rates has been observed in Malaysia in the last few years which is quite alarming [1]. This issue has become a grave concern among the public since many Malaysian graduates are affected by the increasing unemployment rate. It is fascinating to note that the rate of unemployment among youth escalated dramatically by 1.2 % from an estimation of 9.5 % to 10.7 % compared to that of the national unemployment rate which increased only by 0.2 % from 2.9 % to 3.1 % [2]. These statistics clearly indicate that the youth category impacts the rate of the unemployment the most in Malaysia [2]. In addition, based on the study carried out by Law [3], there are about six out of ten people below the age of 24 without a job. Malaysia is producing more than 250 000 graduates every year. However, around 26 % of bachelor degree holders are unemployed among these fresh graduates with tertiary education qualification [1]. Therefore, the current scenario whereby one in five fresh graduates remain unemployed after 6 months of graduation is worrisome [1]. The statistics reveal that around 50 % of the unemployed fresh graduates are from public universities and the remaining 47 % from private universities. This phenomenon is challenging as it may reflect rather poorly on the
Malaysian education system and this may result in some business firms failing to acknowledge the potential of our local graduates.

There are many factors that contribute to the high joblessness rate in Malaysia namely inflation, gross domestic product (GDP) and expansion in population growth. Along with these factors, mediocrity may be the key contributor towards job redundancy problem among the Malaysian graduates. This is signified by findings reported from a survey carried out by The Malaysian Ministry of Higher Education on local fresh graduate which revealed that Malaysian public university graduates who are without a job have poor attitude, lack of English proficiency and poor communication skills [4]. In addition, graduates lack the suitable skills and qualifications essential to fulfil the demands of the industries according to many Malaysian employers which inevitably provides an unfavourable perception towards the graduates [5]. Besides, the graduates are weak in the aspect of employability skills and do not show a good working performance.

A study conducted by Central Bank of Malaysia also found that the Malaysian graduates are less skilled as compared to the international graduates. The skills include but not limited to technical skills, problem-solving skills and communication skills, especially in English language [6]. Furthermore, the graduates are unable to put into practice the curriculum acquired from higher learning institutions [6]. There are numerous jobs which do not emphasize on experiences and thus, graduates need to enhance their view point and personality as advised by JobStreet’s manager [7]. Having said this, there is a report stating that job vacancies are increasing from year to year based on information from resources of job vacancies and job placement in Peninsular Malaysia in 2017. However, these job vacancies are only partly filled by fresh graduates. This shows that the unemployment issue happened not because of the lack of job opportunities instead it occurs because of other factors namely the low quality of a graduate. As a result, immediate and effective measures have to be implemented in order to improve the traits of Malaysian graduates.

The National Graduate Employability Blueprint 2012-2017 outlines the employability attribute framework which encompassed of academic, personality management, exploration, and connectivity attributes [3] which clearly indicates that academic excellence is just part of the components required by the graduates to be employable. Mastering soft skills which are deemed as the titanic skills is highly mandatory to achieve successful job placement. Soft skills can be developed through STEM (Science, Technology, Engineering and Mathematics) education which promotes and integrates the use of 21st century skills such as creativity, critical thinking and teamwork to name a few [8].

The world is radically experiencing the assimilation of digitalized components in the economy around the globe and for that reason, problem-solving skills in particular, have been recognised as a 21st century skill [9]. Hence, more investment in the development and materialization of problem-solving skills has to be endeavoured by educational systems so that the graduates will be able to adapt to the current and future needs of labour markets around the world [9]. Therefore, Universiti Selangor (Unisel) under the Unisel STEM Mentor-Mentee program has embarked on the journey to educate the students on problem-solving skills through thought-provoking activities mirroring real life applications. The STEM activities are designed to cultivate problem-solving skills among foundation students so that these skills can be developed at the beginning of the university study pipeline. The present study evaluates the role of STEM activities in enhancing problem-solving skills by assessing the responses from the foundation students before and after exposure to STEM activities, respectively. The authors are enthusiastic that the STEM activities intervention will equip the students with the vital skill of problem-solving at the infancy stage of tertiary education to facilitate graduate employability.

2. Methodology
2.1 Chemistry module
Hands-on experience is exceedingly valuable to communicate abstract theory more meaningfully to the students. Performing experimental protocols using real-life materials and scenarios will assist students to visualize and learn how to solve problems more effectively. In the present study, a chemistry-based module was developed with a murder case to be solved. In order to unravel the case, respondents were
required to apply fundamental knowledge on pH and chromatography to identify and eliminate potential substances used in the murder case. This module was designed in such a way to allow respondents to freely plan their moves while gathering clues and information in order to solve the case. The activities from the module were carried out by the foundation student through teamwork and assisted by the mentors of the Unisel STEM Mentor-Mentee program and lecturers as the facilitators [10]. This student-centred program was carried out in order to develop 21st century skills particularly the problem-solving skills, higher-order thinking and research skills among the foundation students in the span of 6 hours. The present study adopted the pre-test post-test approach which is highly acceptable as an exploratory study.

2.2 Respondents
The respondents were students enrolled in foundation programs namely Foundation in Science, Foundation in Information Technology (IT), Foundation in Management and Foundation in TESL (Teaching English as Second Language) at the Centre for Foundation and General Studies (CFGS), Universiti Selangor (Unisel), Malaysia. A total of 100 students participated in this study of which 32 were male students and 68 were female students.

2.3 Instrument and procedure
The instrument was a lecturer-made survey consisting of questions related to problem solving skills. A set of questionnaires which employed the Likert Scale with five degrees of agreement (1=strongly disagree to 5=strongly agree) was employed in the present study as the research instrument in evaluating students’ perception of their problem-solving skills. The construct, content and language of the set of questionnaires have been tested and verified by experts confirming the validity of the survey. This survey was given to the respondents before they were exposed to the STEM activities and again after they have completed the STEM tasks. The main objective of the survey was to determine how the exposure to STEM activities can enhance the problem-solving skills among the students.

2.4 Data analysis
The outcome of the case study was evaluated at the beginning and at the end of the program via a set of questionnaires answered by participants and analysed by using Statistical Package for the Social Science (SPSS).

3. Results and discussion
The present research study involved 100 participants from Unisel foundation students. The respondents were between the age of 17 to 22 years old. Among these students, 73 % were from national secondary schools and the remaining students were from religious schools, private schools and boarding schools, respectively.

Figure 1 shows the findings obtained from the following survey question of “how long do you normally stick with a problem?” Figure 1 depicts the results obtained from 100 respondents before the start of the STEM activities program indicating the initial perception of the students. Fifty-eight students responded that they will normally stick with a problem and work smart and creatively until they find the solution for the said problem whilst the rest agreed that they will seek help to resolve the challenges if they could not find the solutions themselves. It was awe-inspiring to find that all respondents were determined not to quit until the problem was sorted out.
Figure 1: Feedback of the respondents on how long they normally stick to a problem at the beginning (pre-test) and at the end (post-test) of the STEM program. Statistically significant differences (p < .05) were observed among the tested group.

The foundation students responded very encouragingly during the pre-test stage of the study regarding the time threshold for problem solving. The minimum entry requirement for foundation programs in Unisel is 5 credits in Sijil Pelajaran Malaysia (SPM) indicating that these students have relatively good academic background and therefore are adequately equipped with curiosity and perseverance to solve problem. In addition, these students also possess certain level of self-esteem and interest in unravelling difficulties [11].

It was fascinating to discover that the respondents reacted more positively to the same survey question after having completed the STEM activities as illustrated in Figure 1. After the accomplishment of STEM tasks, significantly higher number of students (p < 0.05) responded that they will strive to find the most appropriate solution to a given problem resulting in an increase by 21 % of the response. In addition, the foundation students further confirmed that the STEM assignments designed in the Chemistry module were able to lay emphasis on 21st century skills such as problem-solving, teamwork, communication, critical thinking and creativity [12]. Moreover, the participants collectively agreed that being involved and to successfully execute STEM activities had provided them with more confidence to solve problems, improved interaction and communication skills and imparted motivation for adopting teamwork as the best approach to solve problems. The students agreed that it was advantageous to work in a team since it gave them more opportunities to brainstorm various ideas and strategies to solve problems which enabled them to tackle the issues more methodically.

Performing STEM activities required analytical approaches and therefore promoted the students to apply a high level of thinking which was an essential part of problem-solving because it combined real-life problem(s) with applications [13]. Application of real-life materials and scenarios in the STEM inspired Chemistry module improved problem-solving skills among the students. This may be attributed to the fact that that students could relate closely to familiar everyday situations which made the learning process more meaningful [14]. Moreover, the environment presented itself as the learning resources and
thus facilitated mastering of concept and facts related to the STEM tasks [14]. It was also interesting to decipher that conducting STEM activities indeed left a positive impact on students in terms of their problem-solving skills and science process skills. Since real-life applications were involved, students were able to associate with the problems and therefore facilitated the identification and solving of the problems more effectively. The students were also more spirited to seek external help through mentors, facilitators, reading and internet sources to encounter the problems which suggested that STEM activities made the students to be more resourceful. Collectively, it was found that carrying out STEM activities had enhanced the development of collaborative problem-solving abilities through an important metacognitive skill.

It was interesting to note that 57 respondents found that problem solving skills are irrelevant in completing STEM activities during the pre-test stage as depicted in Figure 2. However, this number dropped to 46 when the same survey question was asked after the accomplishment of STEM tasks. Respondents who strongly agree and agree that problem-solving skills are vital skills in completing STEM activities increased by 21 % from 29 students to 35 students during the post-test stage. This clearly reflects the importance of problem-solving skills applicable in STEM program and therefore can be concluded that indeed the participation in STEM program enhanced the problem-solving skills of the respondents.

![Figure 2: Feedback of the respondents on the importance of problem-solving skills. Statistically significant differences (p < .05) were observed among the tested group.](image)

A large body of evidence supported the present findings. Tasir et al [15] revealed that the respondent’s problem-solving skills advanced with the execution of the STEM module based on the data comparison obtained from the pre-test and post-test, respectively. Undertaking activities based on integrated STEM presented the students with the opportunities to explore the process of resolving problems more diligently. Selisne et al [16] published a comprehensive review stating that the STEM integrated activities and modules promoted problem-solving skills and creativity and therefore pushing the boundary beyond knowledge mastery and increased interest in the field of STEM. Alan et al [17] examined the effects of STEM application on pre-service science teachers. The teachers recorded their
experiences in diaries which were analysed at the end of the research study. It was reported chronologically that the respondents faced many challenges while performing the STEM activities and often discouraged in the beginning to find the solutions. However, as they progressed through the completion of the tasks, the respondents were more skilled to solve the problems creatively and researched more ways to encounter the challenges. It can then be summarized that STEM education contributed substantially in sculpting problem-solving skills.

Figure 3 demonstrates the responses of 84 respondents on the importance of certain 21st century skills required to complete the tasks in the Chemistry module. The data in Figure 3 represented the responses from the students focusing specifically in the strongly agree category (Likert scale 5 = strongly agree). Problem-solving skills and teamwork received the most votes from the students, yielding a total response of 22 and 24, respectively. Active listening, critical thinking and creativity in contrast fared moderately compared to that of problem-solving skills, resulting in a total response of 11, 13 and 14, respectively. Foundation students who participated and completed the tasks from the STEM inspired module agreed that this program enhanced their problem-solving skills and they observed that this skill is crucial for securing jobs.

The employers are always looking for graduates who could contribute to real-life situations. This suggests that the employers do not particularly emphasize intensely on qualifications, grades or academic achievement however, rather seek for graduates who excel in a range of 21st century skills (soft skills) such as problem-solving, teamwork, critical thinking, adaptability, perseverance and communications. As a matter of fact, a study conducted by McGunagle and Zizka [18] revealed that problem-solving skills was rated as one of the highest five skills required by the employers for employability. These findings were complemented by the discoveries made by Hossain et al. [5] which stated that the inability to solve problem as one of the top graduate attributes and employability skills...
that led to unemployment among fresh university leavers. Therefore, the graduates need to be proficient at problem solving which will provide them with the extra edge to compete for job placement.

It was postulated that getting involved in extracurricular activities such as STEM program may enhance soft skills. The exposure towards STEM activities will equip the students with the necessary 21st century skills particularly the problem-solving skills as career skills that are indispensable to survive in the globalised job market. The findings from the present study proved that implementing STEM modules and STEM activities successfully enhanced the problem-solving skills as perceived by the foundation students which will be beneficial during job searching.

4. Conclusion

It is important for students to begin associating the possibilities in STEM fields with the need for creativity and real-world problem-solving skills. Our research supports an approach to cultivating interest in STEM subjects through instructional strategies that involve problem solving experiences. This real-world problem-solving approach creates that much needed link between STEM professions and careers that have positive social impact. In addition, STEM careers require the synergy of cross-disciplinary knowledge. Engaging students using problem solving based strategies fosters the ability to develop and enhance this transferable skill and prepares the students for employment. Additional research should look further into the relationship between interest in problem solving to STEM activities and how this would contribute to better job employment.

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