Promoting Students' Interest, Attitude and Intrinsic Motivation Towards Learning STEM Through Minimalist Robot Education Programme

Nur Lisa Zaharin[1], Sabariah Sharif[2], Soon Singh A/L Bikar Singh[3],Rosy binti Talin[4],Muralindran Mariappan[5], Navin Mohanaraj[6],Yusmail Jusup[7] and Pathmanathan A/L Suppiah[8]

[1,2,3,4,5,6,7,8]Universiti Malaysia Sabah (UMS), Sabah, Malaysia

[1]nurlisazaharin@gmail.com;[2]sabariah@ums.edu.my;[3]soonbs@ums.edu.my;[4]rostallin@ums.edu.my;
[5]murali.ums@gmail.com;[6]navinnmohanaraj@gmail.com;[7]yussmile89@gmail.com;
[8]pathmaha@ums.edu.my

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ABSTRACT

Intrinsic motivation is one of the main driving forces for students' interest and attitude towards learning STEM subjects such as Science, Technology, Engineering and Mathematics (STEM). Unfortunately, students' interest and attitude towards STEM subjects are on the decline. A continued decline, if unchecked, will affect the number of students' enrolment into the STEM fields. This study was conducted to investigate the students' interest, attitude and intrinsic motivation towards learning STEM subjects by appraising the pro educational modules that include assembling and dismantling the minimalist robots and by providing software training to the students. The results of hypothesis testing of P-value generated via Statistical Packages of Social Sciences (SPSS) v2.5 indicate the effectiveness of Minimalist Robot Education Programme. The students' interest, attitude and intrinsic motivation show a significant difference towards the learning of STEM. The findings also show that all the alternative hypotheses: (1) students' interest towards learning STEM is increased as a result of participating in the Minimalist Robotic Education Programme; (2); students' attitude towards learning STEM increased as a result of participating in the Minimalist Robotic Education Programme

and (3) students' intrinsic motivation towards learning STEM increased as a result of participating in the Minimalist Robotic Education Programme set for this study.These favorable findings can be a platform for advocating the application of robotics in the Malaysian curricula.

Keywords: *Students' interest; attitude; intrinsic motivation; learning STEM; minimalist robot*

INTRODUCTION

The current decline in the number of students enrolling in the Science, Technology, Engineering and Mathematics (STEM) field is alarming (Kim, 2018). The field of robotics has the potential to attract students' interest via the implementation of Minimalist Robot Education Programme for Form 1 students together with their teachers. Therefore, this paper aims at appraising the proposed Minimalist Robot Education Programme in promoting students' interest, attitude and intrinsic motivation towards learning STEM subjects. Understanding the relationship between intrinsic motivation and their attitude and students' interest through the application of the minimalist robot allows the design of a better Minimalist Robot Education Programme in the future. This paper hence focuses on three objectives: (1) to investigate the students' interest towards learning STEM as a result of participating the Minimalist Robotic Education Programme; (2) to assess the students' attitude towards learning STEM as a result of participating in the Minimalist Robotic Education Programme; and (3) to examine the students' intrinsic motivation towards learning STEM as a result of participating in the Minimalist Robotic Education Programme. 3 alternative hypothesis are also developed in line with the set objectives: (1) students' interest towards learning STEM is increased as a result of participating in the Minimalist Robotic Education Programme; (2); students' attitude towards learning STEM is increased as a result of participating in the Minimalist Robotic Education Programme and (3) students' intrinsic motivation towards learning STEM is increased as a result of participating in the Minimalist Robotic Education Programme.

In the succeeding sections, this paper will provide a literature review of intrinsic motivation in the STEM, an overview of the Minimalist Robot Education Programme and finally, data analysis in presenting the

impact of the programme in promoting interest towards learning STEM, attitude towards STEM and intrinsic motivation towards learning STEM. It is expected that this paper will benefit teachers or industry members that would like to apply the use of educational robot in the classroom to promote interest, attitude and intrinsic motivation among students towards learning STEM subjects.

Overview of Minimalist Robot Education Programme

Program Pendidikan Robot Minimalis (Minimalist Robot Education Programme) is a 3-months outreach programme to promote interest of Science, Technology, Engineering and Mathematics (STEM) field among students. The participants in this programme were 13-year old students, who are in their first year of secondary school i.e. Form 1. The programme started off with a Training of Trainers (ToT) workshop conducted for teachers from 5 schools selected randomly in Kota Kinabalu and Papar, two districts in Sabah, West Malaysia. The aim of this workshop was to train teachers to have simple programming skills of Sctah4Arduino (S4A) so that they could act as facilitators in their respective schools. This workshop aimed to project interest towards Minimalist Robotics among teachers and to allow them to acquire a set of programming and robotic skills to be taught to students. The duration of this ToT workshop was 64 hours. The syllabus applied in the workshop compromised 4 parts:

- Introduction of Sequential Thinking - This provided exposure to teachers on the ability to think as robots. The exposure of the syllabus aimed to guide teachers in designing flow charts in giving commands to the movement of the robots. Robots are considered one of the 'tangible' objects that have the ability to project the creativity of the user's mind (Papert, 1980).
- Introduction to the Hardware of the Minimalist Robot - Teachers were exposed to the components inside the Minimalist Robot in hopes to remove any fear and misconception towards the minimalist robots. They were required to dismantle the hardware components of the minimalist robot step-by-step in order for them to familiarise themselves with the functions of the hardware components of the minimalist robots. Once dismantling was done, they were then required to re-assemble the hardware components back to their original

positions. The newly assembled minimalist robots were then tested in terms of their functionality.

- Introduction to the S4A Programming - During this part of the syllabus, teachers were exposed to the design interface, blocks and function of the Scratch4Arduino (S4A) programming. On top of that, they were introduced to the connectivity of the S4A and the minimalist robotics, *Comel*. They were then introduced to the basic movement of the robotics, such as moving forward, moving back, turning right and vice versa. They were guided with step-by-step instructions with the help of trained facilitators of the programme.
- Advanced S4A Programming - This involved advanced programming of S4A in terms of the minimalist robots' movement. The advanced programming included coding to move the robots in routes that had designated obstacles. The designated obstacles included time-challenging routes and the ability of the minimalist robotics to follow the line track according to its sensor.

This was then continued with the same ToT workshop to the students from the same school, where the same set of syllabus was also introduced to the students. However, it was noticeable that students took a shorter duration than the teachers, which was only 16 hours to complete the workshop, compared to 64 hours taken by the teachers.

All the participants from the Minimalist Robot Education Programme were then invited to participate in the Science, Technology, Education and Mathematics (STEM) Carnival that was conducted over a duration of 4 weeks after the Training of Trainers (ToT) with the students were completed. In this carnival, competitions involving minimalist robotics and other categories of the STEM field such as Compost Bottle and STEM Booth Exhibitions were also included. The aim of the carnival was to attract the students' interest through the various competitions that were held in different categories of the STEM carnival. The diverse categories of the STEM Carnival upheld the STEM concepts that required students who participated in this carnival to create new invention and ideas which advocated the highest order of learning in the Bloom's Taxonomy. In addition, the participation of students into the STEM Carnival was able to sharpen their Higher Order Thinking Skills (HOTS) in knowledge that they ventured into as they were required to link their invention or production based on their understanding of the STEM concepts.

Meanwhile, in the Minimalist Robotic category, students who participated were required to challenge themselves into three categories of (i) Gamification of Minimalist Robot (ii) Maze Challenge and (iii) Booth Exhibition. All of which applied the knowledge obtained from the previous *Training of Trainers* (ToT) that the students had participated in. Nevertheless, the participation of students into competitions was also to promote students' intrinsic motivation through skills instilled throughout the challenges outlined for them such as computational thinking, collaboration and cooperation skills. These skills are vital for student nowadays as the demand for such skills to be used in the workforce in this 21st century is fundamental. Unfortunately, these skills are still lacking among students (Wrahatnolo, 2018) and the need to advocate them is crucial indeed.

LITERATURE REVIEW

Intrinsic motivation among students is vital as it has become one of the elements for students to promote learning. It is defined by a behaviour that arises within an individual to drive them to work within their will and no external stimuli are required to push the students into action (Roszenwig & Wigfield, 2016). Intrinsic motivation among students is discussed based on the Self-Determination Theory developed by Deci and Ryan (1985) that addresses the human innate psychological needs, which includes the need to feel: (1) competent; (2) connected; and (3) autonomous. In the students' context, the ability of students to manage learning even after they have left the school indicates that the process of learning has been achieved at par as they have accomplished and have the autonomy of their own learning goals throughout school.

In fact, the literature has proven that the most of the students strive for academic excellence due to their high intrinsic motivation as it provokes better outcome among students in terms of their interest, confidence level and more importantly, enhanced performance (Linnenbrink & Pintrich, 2002) compared to the one who pursue their studies due to extrinsic motivation. This is because an intrinsically motivated person has the drive to impact change in his or her surroundings (Baranek, 1996). On the contrary, extrinsic motivation among students can be defined as a drive for students to learn due to external factors, such as

meeting expectations or rewards (Blake, 2015). Extrinsic motivation is also linked to the fear of punishment if they obtained poor grades. Nevertheless, it is notable that the development of the extrinsic motivation can hinder the ongoing process of intrinsic motivation of a student (Ryan & Deci, 2000).

Yet, in the field of Science, Technology, Engineering and Mathematics (STEM), intrinsic motivation is important among students in order to develop perseverance and persistency especially when conducting experiments. This is because students who conduct experiments in this field will involve repeated measures of experiments and endless trying in order to get values as near as possible to the hypothetical value. In fact, Belli (2017) stated that failure is a part of the qualities needed for one to succeed in the Science, Technology, Engineering and Mathematics (STEM) field as developing hypothesis, proving by testing them are all part of the scientific method foundation itself. Due to this, intrinsic motivation among students plays a vital role in promoting success and learning in this field. Simon *et al.,* (2015) added that variables such as students' achievement goals, their self-efficacy and perceived autonomy support do affect intrinsic motivation among students.

Thus, in order to promote intrinsic motivation in STEM among students, an outreach programme, titled *Program Pendidikan Robot Minimalis* (Minimalist Robot Education Programme) (see Figure 1) was implemented to foster students' interest, attitude and intrinsic motivations towards STEM field through the use of Minimalist Robots of a given named 'Comel' with the application of Scratch4Arduino (S4A) programming. The field of robotics was chosen as robotics is considered as the core integration of mechanical, engineering, computer science and technology field. It is regarded as part of the STEM field (Ronald *et al*., 2010). The use of robots in education is considered demanding as the skills acquired by students venturing into the field are relevant to the current demand of work field (World Economic Forum, 2016). In fact, the skills that are promoted through robots will impact the students' achievement and perception towards the STEM field. Skills like communication and problem solving are amongst the skills being promoted through the use of robots in education (Ebelt, 2012). The use of the term 'Minimalist Robotics' is defined by this paper as the application of robots in education with the minimal use of technology component at a low-cost budget.

Figure 1: The Minimalist Robots 'Comel' that Are Used Throughout the Minimalist Robot Education Programme

RESEARCH METHODOLOGY

The hypotheses tested in this paper uses the quasi-experimental approach which uses questionnaire survey via the pre-test and post-test of the Minimalist Robot Education Programme involving 50 Form 1 students in Kota Kinabalu and Papar, Sabah (see Figure 2), where the majority of the students who joined the programme were male, obtained grade 'D' for Mathematics and 'B' for Science subjects during the *Ujian Penilaian Sekolah Rendah* (UPSR) examination, had not taken any robotic course before and did not take any S4A programming course before joining the Minimalist Robotic Education Programme. The sample size for the population was determined based on the students' participation into the Minimalist Robotic Education Programme.

The pre-test questionnaire was administered to the students before the Training of Trainers (ToT) workshop started, while the post-test questionnaire was given out during the Science, Technology, Engineering and Mathematics (STEM) Carnival that was conducted after 3 weeks of the ToT workshop completion. The questionnaire was designed based on the Test of Science-Related Attitudes (TOSRA) Handbook by Fraser (1981), with the addition of sections of Interest towards STEM and attitude towards STEM The parameters drawn from the TOSRA handbook

included: (1) Interest towards STEM; (2) Fun towards STEM Field; (3) Interest towards Robotics during Free Time; (4) Tendency in Career Selection in STEM Field; and (5) Intrinsic Motivation towards Robotics, but only 3 parameters were included in Section A to Section C of the questionnaire, respectively i.e. Interest towards STEM; (2) Tendency in Career Selection in STEM Field, which represented the students' attitude; and (3) Intrinsic Motivation towards Robotics. The pre-test questionnaire aimed to measure the participants' interest, attitude and intrinsic motivation towards the STEM field before participating in the Minimalist Robotic Education Programme. Meanwhile, the post-test questionnaire aimed to measure the range of the students' interest, attitude and intrinsic motivation towards learning STEM after participating in the Minimalist Robotic Education Programme. Both pre-test and post-test questionnaires were in Bahasa Melayu to ease the response process by the students.

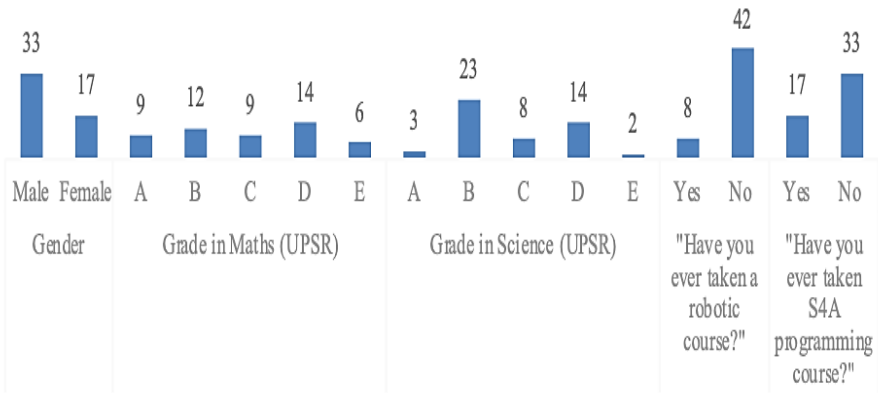

Figure 2: Demographic Data of Students Who Participated in the Minimalist Robot Education Programme

The parameters drawn from the questionnaires in this paper used 42 questions involving 7-Likert-scale, where the reliability and validity had been established (Unfried, Faber, Stanhope & Wiebe, 2015) since an established questionnaire by Fraser (1981) was adopted. The responses to the questionnaire were rated by students on a 7-point Likert-type scale ranging from a scale of "1 = strongly disagree/strongly boring" to "7 = strongly agree/strongly amazing", which shall take approximately from 5 to 10 minutes to answer all the questionnaires. The data was then analysed using Statistical Package of Social Sciences (SPSS) v2.5 by measuring the significance difference between the pre-test and post-test questionnaire,

where values of $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.10$were exhibited as positive significant and also indicated that the alternative hypothesis (Ha) was statistically proven (Dahiru, 2008). Meanwhile, feedbacks from teachers were recorded as part of the qualitative data collection through interviews.

RESULTS AND DISCUSSION

The findings demonstrated an increase for alternative hypotheses of: (1) students' interest towards learning STEM; (2); students' attitude towards learning STEM and (3) students' intrinsic motivation towards learning STEM as a result of participating in the Minimalist Robotic Education Programme.

The results are illustrated in Table 1. Section A: Interest towards STEM shows that the hypothesis testing indicated positive significance on "Science is a subject that is appealing and exciting", "Mathematics is a subject that is appealing and exciting", "Engineering is a subject that is not boring" and "Technology is a subject that is exciting", which show positive interest towards the STEM field among the students in the Robotic Minimalist Education Programme. The p-values obtained also statistically prove the alternative hypothesis of objective 1 i.e. students' interest towards learning STEM is increased as a result of participating the Minimalist Robotic Education Programme. The interests towards STEM field were promoted through teamwork activities that were organised throughout the workshop. In fact, the participants' knowledge in the S4A programming was measured based on their ability to finish the challenges given, such as Obstacle Track and Line Tracking Obstacles, thus the challenges provided pushed them to work collaboratively in order to complete the challenges given. This is because the challenges allow 'hands-on' engagement with actual objects that assist them to spark curiosity and intrigue among them (Khanlari, 2013). Moreover, the ability of developing cooperative learning in robotic challenges acted as a means to promote students' interest towards learning STEM (Mosley, Ardito & Scollins, 2016; Nugent, Barker & Grandgenett, 2016). On top of that, through the Training of Trainers (ToT) workshop that were conducted, the students were given exposure of how each component in the minimalist robot worked and were able to move with the instructions given from the blocks built from the Scratch4Arduino (S4A) programming. For the

students, the ability to move the minimalist robot from the basic movement to the advanced movement was one of the factors for them to be interested to venture into the STEM field. Thus, from the results obtained, it is statistically proven that the minimalist robots are able to increase interest towards STEM field among the participants.

In Section B: In the Tendency in Career Selection in STEM Field that represented students' attitude towards learning STEM, the results showed a positive significance towards the statements "I want to work with inventors after I finish my school", "Working in Science Laboratory is an interesting way to support life" and "Working as a scientist is boring". This indicated that students who participated in the Minimalist Robot Education Programme have a high tendency to work in a STEM-related field. Besides that, the p-value analysis statistically proves that the alternative hypothesis of objective 2, i.e. students' attitude towards learning STEM is increased as a result of participating in the Minimalist Robotic Education Programme. This is because the challenges outlined in the ToT workshop and the STEM Carnival require students to work as a team, thus a high level of perseverance is needed to address the challenges. In fact, the exposure of the students to the extracurricular experiences, such as Minimalist Robot Education Programme stimulates their interest to venture into STEM (VanMeter-Adams et al., 2014).

Meanwhile, the results of Section C: Intrinsic Motivation towards Robotics that exhibited the intrinsic motivation towards robotic presented positive significance in the statements "Minimalist robotics is useful", "Minimalist robotics is fun", "Minimalist robotics will increase my Science grade" and "Minimalist robotics improves my attitude and character in learning Science" of the intrinsic motivation of students who join the Minimalist Robotic Education Programme. The findings of significance proved that intrinsic motivation towards STEM field through robotic minimalist can be fostered among students with the implementation of such programmes. In addition, Apiolaet al. (2010) suggested that intrinsic motivation and the element of creativity among students can be promoted through the students' experimentation with robots in robotic workshop. Surprising, "I do not have choice other than to do minimalist robotics" also recorded positive significance. This is probably affected by the questionnaire survey that was adopted from the well-established questionnaire developed by Fraser (1981). Although some

amendments had been made to the questionnaire as to suit the Minimalist Robotic Education Programme a pilot study was not carried out to test the reliability and internal consistency of the amended questionnaire. For future research, the researchers must put into consideration into setting up a pilot study using the amended questionnaire of Test of Science-Related Attitudes (TOSRA) Handbook by Fraser (1981). However, due to limited time and resources, the researchers were not able to perform pilot study with the administered questionnaire.

Table 1: Results of Hypothesis Testing

Items	Parameter	Standard Error Mean	Significance (p-value)
Section A: Interest towards STEM			
Science is a subject that is:	Amazing	0.10	0.18
	Appealing	0.12	0.08
	Exciting	0.13	0.07
	Meaningful	0.13	0.28
	Not boring	0.12	0.11
Mathematics is a subject that is:	Amazing	0.16	0.88
	Appealing	0.16	0.01
	Exciting	0.17	0.01
	Meaningful	0.17	0.20
	Not boring	0.17	0.10
Engineering is a subject that is:	Amazing	0.13	0.27
	Appealing	0.13	0.13
	Exciting	0.12	0.13
	Meaningful	0.86	0.11
	Not boring	0.13	0.06
Technology is a subject that is:	Amazing	0.13	0.14
	Appealing	0.14	0.25
	Exciting	0.13	0.10
	Meaningful	0.13	0.12
	Not boring	0.13	0.14
Section B: Tendency in Career Selection in STEM Field			
I do not want to be a scientist after I finish my school		0.13	0.37
I want to work with inventors after I finish my school		0.12	0.04
I do not want to work in Science Laboratory after I finish my school		0.12	0.86
Working in Science Laboratory is an interesting way to support life		0.12	0.00
Profession in Science is boring		0.10	0.16
I plan to teach Science subject after I		0.12	0.32

finish my school		
Working as a scientist is boring	0.14	0.00
Working as scientist is exciting	0.19	0.32
I do not want to become a scientist because it takes long time to learn	0.12	0.42
I want to become a scientist after I finish my school	0.13	0.22
Section C: Intrinsic Motivation towards Robotics		
Minimalist robotics is useful	0.12	0.00
Other activity is more useful than robotics	0.13	0.64
Minimalist robotics is fun	0.12	0.00
I like doing robotics	0.14	0.42
Robotics is boring	0.11	0.77
Robotics is useful	0.14	0.16
Minimalist robot will increase my Science grade	0.13	0.04
Minimalist robotics is important in improving my skills in Science and Mathematics	0.15	0.17
Minimalist robot improves my attitude and character in learning Science	0.13	0.01
I feel forced to do minimalist robotics	0.14	0.20
I am not willing to redo minimalist robotics	0.16	0.13
I do not have choice other than to do minimalist robotics	0.11	0.09

The findings from the analysis were aligned to the objectives of this study which was (1) to investigate the students' interest towards learning STEM as a result of participating in the Minimalist Robotic Education Programme; (2) to assess the students' attitude towards learning STEM as a result of participating in the Minimalist Robotic Education Programme. The values of $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.10$ are exhibited as positive significant and are also indicating that the alternative hypothesis (Ha) is statistically proven (Dahiru, 2008). For this reason, the alternative hypothesis for (1) students' interest towards learning STEM is increased as a result of participating the Minimalist Robotic Education Programme; and (2); students' attitude towards learning STEM is increased as a result of participating the Minimalist Robotic Education Programme are acceptable for this study.

Other than that, regression analysis was performed in order to study the relationship between the students' interest towards learning STEM and the students' attitude towards learning STEM with the students' intrinsic motivation who participated in the Minimalist Robotic

Education Programme. The results of the regression analysis between items from Section A: Interest towards STEM Section C: Intrinsic Motivation are illustrated in Table 2.

Table 2: Regression Analysis between Students' Interest towards STEM and Their Intrinsic Motivation towards Robotics

Items	Parameter	Significance (p-value)
Intrinsic Motivation 1	Science is a subject that is appealing	0.13
	Science is a subject that is exciting	0.41
	Mathematics is a subject that is appealing	0.01
	Mathematics is a subject that is exciting	0.01
	Engineering is a subject that is meaningful	0.11
	Technology is a subject that is exciting	0.24
Intrinsic Motivation 2	Science is a subject that is appealing	0.50
	Science is a subject that is exciting	0.12
	Mathematics is a subject that is appealing	0.42
	Mathematics is a subject that is exciting	0.26
	Engineering is a subject that is meaningful	0.01
	Technology is a subject that is exciting	0.11
Intrinsic Motivation 3	Science is a subject that is appealing	0.09
	Science is a subject that is exciting	0.09
	Mathematics is a subject that is appealing	0.03
	Mathematics is a subject that is exciting	0.01
	Engineering is a subject that is meaningful	0.02
	Technology is a subject that is exciting	0.00
Intrinsic Motivation 4	Science is a subject that is appealing	0.25
	Science is a subject that is exciting	0.42
	Mathematics is a subject that is appealing	0.43
	Mathematics is a subject that is exciting	0.14
	Engineering is a subject that is meaningful	0.01
	Technology is a subject that is exciting	0.48
Intrinsic Motivation 5	Science is a subject that is appealing	0.08
	Science is a subject that is exciting	0.15
	Mathematics is a subject that is appealing	0.00
	Mathematics is a subject that is exciting	0.00

	Engineering is a subject that is meaningful	0.36
	Technology is a subject that is exciting	0.05
Intrinsic Motivation 6	Science is a subject that is appealing	0.15
	Science is a subject that is exciting	0.46
	Mathematics is a subject that is appealing	0.04
	Mathematics is a subject that is exciting	0.01
	Engineering is a subject that is meaningful	0.01
	Technology is a subject that is exciting	0.01
Intrinsic Motivation 7	Science is a subject that is appealing	0.06
	Science is a subject that is exciting	0.33
	Mathematics is a subject that is appealing	0.13
	Mathematics is a subject that is exciting	0.01
	Engineering is a subject that is meaningful	0.09
	Technology is a subject that is exciting	0.12
Intrinsic Motivation 8	Science is a subject that is appealing	0.01
	Science is a subject that is exciting	0.14
	Mathematics is a subject that is appealing	0.14
	Mathematics is a subject that is exciting	0.01
	Engineering is a subject that is meaningful	0.03
	Technology is a subject that is exciting	0.03
Intrinsic Motivation 9	Science is a subject that is appealing	0.01
	Science is a subject that is exciting	0.23
	Mathematics is a subject that is appealing	0.20
	Mathematics is a subject that is exciting	0.08
	Engineering is a subject that is meaningful	0.00
	Technology is a subject that is exciting	0.02
Intrinsic Motivation 10	Science is a subject that is appealing	0.17
	Science is a subject that is exciting	0.38
	Mathematics is a subject that is appealing	0.26
	Mathematics is a subject that is exciting	0.28
	Engineering is a subject that is meaningful	0.15
	Technology is a subject that is exciting	0.11
Intrinsic Motivation 11	Science is a subject that is appealing	0.17
	Science is a subject that is exciting	0.38
	Mathematics is a subject that is appealing	0.26

	Mathematics is a subject that is exciting	0.28
	Engineering is a subject that is meaningful	0.15
	Technology is a subject that is exciting	0.11
Intrinsic Motivation 12	Science is a subject that is appealing	0.00
	Science is a subject that is exciting	0.12
	Mathematics is a subject that is appealing	0.04
	Mathematics is a subject that is exciting	0.04
	Engineering is a subject that is meaningful	0.06
	Technology is a subject that is exciting	0.33

In analysing the regression analysis in Table 2, a low p-value of <0.05 indicates a rejection to the null hypothesis stated. In other words, the alternative hypothesis (Ha) outlined in this study are accepted and have a meaningful significance and a high association between the variables accepted (Editor, 2013). Thus, from the Table 2, a positive significance is exhibited between the items from Section C: Intrinsic Motivation 1 which is "I believe that doing this robotic activity is very useful to me" This is strongly related to the statements "Mathematics is a subject that is appealing" and "Mathematics is a subject that is exciting" with p-value of 0.01 obtained. The positive significance between the variable proves that students are aware that the robotic activities in the programmes does have links to knowledge of Mathematics. This result concurs with the study of Ronald et al. (2010) which indicated that robotics is part of the STEM field.

However, statement from intrinsic motivation items, "I have a choice other than doing this robotic activity", correlates positively to the statement of "Engineering is a subject that is meaningful". This suggests that students do believe that engineering is a wide field to be explored and are not limited to the robotic field. High correlation are observed from the item from intrinsic motivation 3 and 8 : "This robotic activity is fun" and "I think robotic activity is important to increase my skills in Science and Mathematics" and the statements from section A; students' interest towards STEM of "Science is a subject that is appealing", "Mathematics is a subject that is appealing", "Mathematics is a subject that is exciting", "Engineering is a subject that is meaningful" and "Technology is a subject that is exciting". Findings are then continued with item 4 from intrinsic motivation section which demonstrated a positive relationship between

statement of "I made this robotic activity because I wanted to do it" and "Engineering is a subject that is meaningful". The positive relationship indicated that the relationship between students' interest towards STEM with their own intrinsic motivation towards the robotic field. However, it is notable that high correlation are exhibited between the statement from the intrinsic motivation section of "I feel this robotic activity is boring" with the variables of "Mathematics is a subject that is appealing", "Mathematics is a subject that is exciting" and "Technology is a subject that is exciting". Inconsistent findings are demonstrated, yet it contradicts with the subsequent statement from the intrinsic motivation section of "I am willing to do this robotic activity because I think that the activity is very useful" as it presented a high significance with variables of "Mathematics is a subject that is appealing", "Mathematics is a subject that is exciting", "Engineering is a subject that is meaningful" and "Technology is a subject that is exciting". Meanwhile, a similar positive pattern is seen in the 7th statement from the intrinsic motivation section: "I believe doing robotics will increase my grade in Science subjects" with variables of "Mathematics is a subject that is appealing". Furthermore, positive significance are also observed from the 9th and the 12th statement from the Section C: Intrinsic motivation with variables of "Science is a subject that is appealing", "Mathematics is a subject that is appealing", "Mathematics is a subject that is exciting", "Engineering is a subject that is meaningful" and "Technology is a subject that is exciting". Table 2 shows that most of the results indicated high significance between the students' intrinsic motivation towards robotics and students' interest towards STEM.

It can be surmised therefore that the findings from the analysis are aligned to the objectives of this study which is (3) to examine the students' intrinsic motivation towards learning STEM as a result of participating the Minimalist Robotic Education Programme. A low value of $p \leq 0.05$ indicates positive correlation of students' interests which are able to spark the students' intrinsic motivation towards robotics. For this reason, the alternative hypothesis for (3) students' intrinsic motivation towards learning STEM is increased as a result of participating the Minimalist Robotic Education Programme are accepted for this study.

Moreover, students' attitude towards learning STEM and its impact towards students' intrinsic motivation are also being investigated by using similar regression analysis. The results are illustrated in Table 3 below:

Table 3: Regression Analysis between Students' Attitude towards STEM and Their Intrinsic Motivation towards Robotics

Item	Parameter	Significance (p-value)
Intrinsic Motivation 1	When I've finished studying, I want to work with people who make new discoveries	0.42
	Working in the Science Laboratory is an exciting way to support life	0.08
	Career in the field of Science is boring	0.27
Intrinsic Motivation 2	When I've finished studying, I want to work with people who make new discoveries	0.45
	Working in the Science Laboratory is an exciting way to support life	0.43
	Career in the field of Science is boring	0.14
Intrinsic Motivation 3	When I've finished studying, I want to work with people who make new discoveries	0.01
	Working in the Science Laboratory is an exciting way to support life	0.13
	Career in the field of Science is boring	0.00
Intrinsic Motivation 4	When I've finished studying, I want to work with people who make new discoveries	0.12
	Working in the Science Laboratory is an exciting way to support life	0.13
	Career in the field of Science is boring	0.03
Intrinsic Motivation 5	When I've finished studying, I want to work with people who make new discoveries	0.01
	Working in the Science Laboratory is an exciting way to support life	0.17
	Career in the field of Science is boring	0.17
Intrinsic Motivation 6	When I've finished studying, I want to work with people who make new discoveries	0.08
	Working in the Science Laboratory is an exciting way to support life	0.02
	Career in the field of Science is boring	0.26
Intrinsic Motivation 7	When I've finished studying, I want to work with people who make new discoveries	0.04
	Working in the Science Laboratory is an exciting way to support life	0.02
	Career in the field of Science is boring	0.00

Intrinsic Motivation 8	When I've finished studying, I want to work with people who make new discoveries	0.04
	Working in the Science Laboratory is an exciting way to support life	0.00
	Career in the field of Science is boring	0.00
Intrinsic Motivation 9	When I've finished studying, I want to work with people who make new discoveries	0.00
	Working in the Science Laboratory is an exciting way to support life	0.00
	Career in the field of Science is boring	0.01
Intrinsic Motivation 10	When I've finished studying, I want to work with people who make new discoveries	0.43
	Working in the Science Laboratory is an exciting way to support life	0.50
	Career in the field of Science is boring	0.32
Intrinsic Motivation 11	When I've finished studying, I want to work with people who make new discoveries	0.11
	Working in the Science Laboratory is an exciting way to support life	0.38
	Career in the field of Science is boring	0.29
Intrinsic Motivation 12	When I've finished studying, I want to work with people who make new discoveries	0.00
	Working in the Science Laboratory is an exciting way to support life	0.01
	Career in the field of Science is boring	0.01

From the results demonstrated in Table 3, it can be seen that positive significance is demonstrated between the statements from the intrinsic motivation section which is "This robotic activity is fun" with the statement of "When I've finished studying, I want to work with people who make new discoveries" and "Career in the field of Science is boring" from Section B: Tendency in Career Selection in STEM Field which represents the students' attitude towards STEM field. Yet, the following findings contradicts the intrinsic motivation statement "I joined the robotic activity because I want to" which demonstrated positive correlation with statements of "Career in the field of Science is boring". In fact, high correlation is also exhibited between the intrinsic motivation statement of "I feel that robotic activity is boring" and "When I've finished studying, I want to work with people who make new discoveries". This correlation

indicates that students are inclined to venture into different parts of the STEM field besides robotic field. Besides that, positive significance is observed from the intrinsic motivation statement of "I am willing to do robotic activity because I feel that this activity is useful" with the statement which represents the students' attitude towards STEM which are "Working in the Science Laboratory is an exciting way to support life". This relationship indicates that students who participated in the robotic activities outlined in the programme have the tendency to choose STEM related field as their career. It proves that students' participation have changed their attitude to explore STEM related field.

Meanwhile, the 7^{th} , 8^{th} , 9^{th} and the 12^{th} intrinsic motivation statement "I believe doing robotics will increase my grade in Science subjects", "I think robotic activity is important to increase my skills in Science and Mathematics" , "This activity can improve my attitude and habits of studying Science" and "I do not have choice other than to do minimalist robotics" are also positively correlated to statements of "When I've finished studying, I want to work with people who make new discoveries", "Working in the Science laboratory is an exciting way to support life" and surprisingly, "Career in the field of Science is boring" demonstrate a change in the students' attitude towards STEM field as a result of participating the Minimalist Robotic Education Programme.

Thus, the findings from the analysis are aligned to the objectives of this study which is (3) to examine the students' intrinsic motivation towards learning STEM as a result of participating in the Minimalist Robotic Education Programme. Low value of $p \leq 0.05$ indicates positive correlation students' interest which is able to spark the students' intrinsic motivation towards robotics. For this reason, the alternative hypothesis for (3) students' intrinsic motivation towards learning STEM is increased as a result of participating in the Minimalist Robotic Education Programme are accepted for this study. Therefore, the findings from the analysis are aligned to the objectives of this study which is (3) to examine the students' intrinsic motivation towards learning STEM as a result of participating in the Minimalist Robotic Education Programme. A low value of $p \leq 0.05$ indicates positive correlation students' interest which is able to ignite the students' intrinsic motivation towards robotics. For this reason, the alternative hypothesis for (3) students' intrinsic motivation towards learning STEM is increased as a result of participating the Minimalist Robotic Education Programme are acceptable for this study.

Overall, the students' interest, attitude and intrinsic motivation show a significant difference towards the learning of STEM. The findings also show that all the alternative hypotheses: (1) students' interest towards learning STEM is increased as a result of participating the Minimalist Robotic Education Programme; (2); students' attitude towards learning STEM is increased as a result of participating the Minimalist Robotic Education Programme and (3) students' intrinsic motivation towards learning STEM is increased as a result of participating in the Minimalist Robotic Education Programme. This also proves that educational robotics, such as the Minimalist Robot can provide an innovative way in teaching and learning of the STEM subjects. This is proven by the study of Gyebi, Hanheide and Cielniak, (2016) which applied Educational Robotics (ER) in classrooms and presented better results in terms of the students' motivation, engagement and their level of understanding towards a subject. Lerch (2018) even added that integrating Educational Robotics (ER) in classrooms would benefit students through (i) creative thinking (ii) more engagement towards concepts of a subject (iii) as a way of preparing them for the constant and rapid technological changes (iv) developing programming skills among students (vi) creating perseverance (vii) creating teamwork and collaborative skills among students and lastly (viii) providing a fun learning experience among students.

However, concerns such as (i) Lack of confidence in handling minimalist robot and Scratch4Arduino (S4A) programming among teachers (ii) Lack of resources and expertise in programming (iii) Lack of idea and creativity in integrating Minimalist Robot into the Malaysian education syllabus and (iv) Limited time to use Minimalist Robot in the classroom environment as teachers need to complete syllabus within the designated period of time were addressed by the teachers who participated the *Training of Trainers* (ToT) workshop of the Minimalist Robotics Education Programme. This is supported by the study conducted by Smyrnova-Trybulska*et al.,* (2016) which indicated that most of the teachers would like to use educational robotics (ER) in classrooms yet the major issue is the 'lack of confidence' in using them. This may be contributed to the age gap difference of the teacher who participated in our *Training of Trainers* (TOT) workshop as most of them were aged between 30 – 45 years old.

Meanwhile, regarding the concerns 'Lack of resources and expertise in programming', Akbar (2015) stated that Malaysia has a limited number of experts in the programming field. Due to this, the limited experts are not able to teach teachers basic programming such as Scratch4Arduino (S4A) programming and does not know how to apply the functionality of basic programming into the Malaysian education system. Other concern includes the funds to set up such programmes. In fact, some of them do not feel the need to learn the basic programming skills as they perceive them as part of Information and Communication Technology (ICT) (Ling, Saibin, Labadin, & Aziz, 2017). Thus, the need to change the certain perceptions towards programming skills is crucial due to the fact that teachers play a vital role in producing digital and competent students. On the other hand, with regard to the concerns 'Lack of idea and creativity in integrating Minimalist Robot into the Malaysian education syllabus' and 'Limited time to use Minimalist Robot in the classroom environment as teachers need to complete syllabus within a designated period of time', Chevalier, Riedo and Mondada (2016) stated that teachers do feel that educational robotics (ER) are important for the students' motivation, however, they do not know how to use them as a tool in the classrooms.

Nevertheless, these concerns can be resolved through efforts such as conducting series of workshop such as the *Training of Trainers* (ToT) workshop which provide resources and expertise of the Scratch4Arduino (S4A) programming to the teachers. In fact, the *Training of Trainers* (ToT) workshop for the Minimalist Robotics Education Programme was able to instil collaborative and creativity skills among teachers as well as their participation into such programmes which allowed more exposure and experience in applying minimalist robot in classrooms.

Although teachers need more time to learn the Scratch4Arduino (S4A) programming during the *Training of Trainers (*ToT) workshop compared to the students themselves, it is still practical as the training for the use of the Minimalist Robotics only requires 4 days of training. Kim *et al*., (2015), for example investigated the impact of educational robotics courses to pre-service teachers and exhibited active engagement among teachers involved.

CONCLUSION

In conclusion, the findings from this paper indicated thatstudents' interest, attitude and intrinsic motivation towards learning STEM can be advocated through an outreach programme such as in this study. However, the findings from this from this study can be improved through conducting a pilot study to investigate the reliability and internal consistency of the amended questionnaire used throughout the study. Future research for this study includes conducting a pilot study, more participants for the programme and data collection via face-to-face interview from students in order to obtain a conclusive evidence towards the study.

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