

Critical Factors that Contribute to the Implementation of the STEM Education Policy

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Abstract

STEM is a highly regarded area internationally. Malaysia also does not want to miss out on developing the STEM field. We want to develop local expertise in this field so that we are able to grow in line with other countries. Thus, Malaysia has implemented a 60:40 policy which targets 60 percent of students to be in the STEM field. In the early stages of this policy implementation, this policy was known as the 60:40 Science/technical:Literature. In line with current developments, 60:40 policy is changed to STEM:Non-STEM as stated in Malaysia Education Blueprint 2013-2025. Various programs are implemented to achieve this policy objective. However, the target of 60 percent of students in the STEM field is still unreachable. Therefore, this study focuses on the exploration of critical factors that influence the implementation of this policy. This is a qualitative study in which the semi-structured interview method involves eight respondents. The results of the interviews have been analyzed thematically. Based on the findings, four critical factors have been identified which contribute to the implementation of the 60:40 policy. The critical factors are student factors, school factors, parent factors and administrator factors.

Keywords: 60:40 Policy, STEM Education, Student's Interest, Self-Efficacy, Administrator.

Introduction

STEM was first introduced around 1990 by the National Science Foundation in the USA. The results of unifying the Science, Technology, Engineering and Mathematics that make up STEM are made by scientists, technologists, engineers and mathematicians (California Department of Education, 2014). This is because scientists believe STEM will develop the economy and open up the career opportunities broadly (Williams & Ceci, 2012).

According to Sanders et al. (2011), STEM education involves the integration of Science and Mathematics with technology and engineering skills (Ishikawa & Moehle, 2013). Becker and Park (2011) considered STEM education to be the process of exploring any STEM component or combining STEM components with other disciplines. The exploration of the STEM field is believed to provide many future job opportunities (William & Cechi, 2012). Therefore, according to McPherson (2014), it is important to create a generation who is equipped with knowledge and skills that are related to STEM in order to produce more

expertise and workforce in the STEM field. As a result, the 60:40 policy is implemented in Malaysia to increase local expertise in this field.

Problem Statement

Mastery of knowledge and skills in the field of STEM is very important in today's development. The STEM field has been acknowledged to contribute to economic development and innovation (Fulton & Britton, 2016; Riegle-Crumb & King, 2010). In addition, the field also provides a variety of exciting job opportunities (William & Cechi, 2012). Hence, STEM education needs to start from the school level to ensure students have the tendency to choose this field when pursuing tertiary education (Kier, Blanchard, Osborne & Albert, 2014). Thereby, the Malaysia government is taking the initiative to implement the 60:40 policy to increase the number of student participation in this area.

In the early stages of implementation in 1970, this policy was known as the 60:40 Science/Technical:Literature. Subsequently, it has been changed to 60:40 STEM:non-STEM as listed in the Malaysian Education Development Plan (PPPM) 2013-2024 (Malaysia Ministry of Education, 2013). This policy targets at least 60 per cent of students in the STEM field. In order to achieve the target of 60 per cent of STEM students in Malaysia secondary schools, various activities are carried out by the ministry and state education departments (Malaysia Ministry of Education, 2012; 2016). Although various activities and programmes are being implemented to support this policy, but the issue on the lack of students who tend to choose the STEM field remains unresolved (Malaysia Ministry of Education, 2015). The highest percentage of students in STEM in 2012 was 46.83% (Malaysia Ministry of Education, 2012). This means that the percentage of students in the STEM field has not reached the target of 60 per cent as required by the policy and this has resulted in the country having less STEM talent among locals (Malaysia Academy of Science, 2015).

According to Yazilitas, Svensson, Vries and Saharso (2013), there are two factors that influence the decreasing of students in STEM field, namely the self-factor and the environmental factors. Self-factor refers to individual personal factors, while environmental factors are associated with factors that are related to the individual environment (Ing, 2013). The self-factors that influence the involvement of students in the STEM field are interest, confidence, motivation and achievement in Science/ Mathematics (Leaper, Farkas & Brown, 2012; Weeden, Gelbgiser & Morgan, 2015; Morgan, Gelbgiser & Weeden, 2016). Meanwhile, environmental factors affecting the choice of STEM are family support, peer influence and career opportunities (Leaper et al., 2012; Norbahiah et al., 2012; Balakrishnan, Foon & Mohamed, 2015). However, Halpern et al. (2007) stated that the combination of self-factors and environmental factors have influenced the involvement of students in STEM (Yazilitas et al., 2013; Else-Quest, 2013; Balakrishnan et al., 2015).

Hence, based on the issue, the researcher is conducting this survey to explore the factors that have caused the 60:40 policy to be unachievable. Previous studies conducted related to STEM education were using qualitative methods (Malaysia Ministry of Education, 2016). Due to that reason, this study was conducted using expert interview methods. By using interview method, researcher can explore other issues arising from the implementation of STEM education in schools.

Purpose of Study

This study explores the factors that influence the implementation of 60:40 STEM:non-STEM education policy in Malaysian secondary schools.

Method

This study uses the semi-structural interview methods. Through interviews, researchers will gain a deeper perspective on the issues studied (Cohen, Manion & Morrison, 2007; Othman, 2007; Merriam, 2009; Creswell, 2012). According to Turner (2010) and Creswell (2012), semi-structured interviews provide guidance and help researchers to conduct interviews in a well-organised and efficient manner. The number of respondents involved in this study comprised of eight education service officers who had served more than five (5) years as suggested by Adler and Ziglio (1996) and Clayton (1997).

Result

The achievement of 60:40 STEM:Non-STEM policy is highly debate by people who are aware of the STEM education in Malaysia. Various study had been carried out in various issues related to this policy. This study focuses on a critical factors that contribute to the implementation of the STEM education policy by interviewing the education service officers who have served more than five years and possessed extensive experience and knowledge related to education. Table 1 below is the demographics of the respondents who have been interviewed.

Table 1
Demographic of respondents

Respondent	Gender	Duration of service (year)
P1	Male	20
P2	Male	18
P3	Female	17
P4	Male	13
P5	Male	30
P6	Male	31
P7	Female	28
P8	Female	34

All interviews were analysed thematically to identify the appropriate themes to ensure that they are in line with the research conducted. After analysing the results, the interviews have been categorised into four main themes, namely student factors, school factors, parent factors and administrator factors. These four factors are identified as factors that influence the implementation of the 60:40 STEM:Non-STEM policy in school. Here are quotes from the interview sessions.

Student Factors

All the respondents who were interviewed agreed that the student factors have influenced the implementation of the 60:40 policy. The result of the interview shows that the student factors are related to interest, self-confidence, motivation and achievement of Science and Mathematics in the Form 3 Assessment (F3A). It relies on the views of experts as follows.

"..... students who are not interested in getting into science-related fields, and student also afraid because they feel it's difficult to get good results in the exam." (P1)

".....also an issue, certain students are eligible, but because of their own interests, they do not choose Science, they chose another field." (P2)

"Among those, I know the students' less interest in, so they choose non-STEM field" (P3)

"I think the main factor is the Form 3 Assessment itself. Because the achievement of Science and Mathematics is quite low. Then students have no tendency to choose STEM field" (P4)

"Form 3 Assessment result not good, so hard to study in Science. Another one, they think Science's subject is hard. They lack of confidence." (P5)

"The condition was not achieved because of the student's results in Science and Mathematics in Form 3 Assessment is less encouraging. Furthermore, students are more interested in non-STEM because they feel the Science subjects are difficult, particularly Advance Mathematics" (P6)

"Form 3 Assessment (F3A) result increased compared to the previous year, but Mathematics dropped. I think that F3A kills STEM and 60:40 policy" (P7)

"Students lack the motivation to study in the Science stream because they feel it's a difficult subject." (P8)

Based on the results of the interview, interest is a factor that has often been expressed by the respondents as a factor that prevents students from participating in the STEM field. This can be seen from the opinions expressed by respondents P1, P2, P3 and P6. As such, interest can be formulated as the main factor that affects students to choose the STEM field. According to Krapp (2003) also supported by Katz et al. (2006), interest is a key driver for individuals to do something. According to Griffith (2010) and Morgan et al. (2016), low student interest in STEM have caused them not to choose the STEM field to further their studies. Therefore, students are not inclined to choose the STEM field because they have no interest in this field. As a result, the percentage of students in the STEM field failed to reach 60 percent as targeted by 60:40 policy.

Apart from interest, the respondents (P4, P5 and P7) also argued that the lack of students in this area is due to the low achievement by students in Science and Mathematics in the Form Three Assessment (F3A). This low achievement have caused students not to choose STEM when they are at the upper secondary level. This situation coincides with the opinion of the previous researcher who emphasised that when a student achieves good

results in Science and Mathematics, the student will tend to show some interest in STEM (Xu, 2008; Gafoor & Narayan, 2012; Wang & Degol, 2013). In addition, researchers also argue that the achievement by students in Science and Mathematics will be better if they have an interest in the subject (Gafoor & Narayan, 2012; Hassan, Awang, Ibrahim & Zakariah, 2013; Noor Erma & Leong, 2014). As such, interest has also influenced student achievement in the subject, which will ultimately contribute to the increase in the number of students in the STEM field.

One of the student factors expressed by respondents (P1, P5 and P6) was self-confidence. The respondents expressed their low self-esteem as the students felt that Science and Mathematics subjects were difficult and are afraid they would not obtain excellent results in the examination. This situation coincides with previous researchers who commented that self-esteem is one of the factors that influence the involvement of students in STEM (Faitar & Faitar, 2013; Wang & Degol, 2013; Malaysia Ministry of Education, 2015). In addition, self-confidence is also found to have contributed to student's motivation to do something (Hackett & Betz, 1989; Bandura, 2006). In this case, student confidence in the STEM field will make students more motivated to be in this field. This was stated by respondent (P8) that students are less motivated to choose the STEM field due to their low self-esteem.

Therefore, the findings have identified four sub-factors from the student factors, namely student's interest, achievement of Science and Mathematics, self-confidence and motivation that affects the student's tendency to choose the STEM. Students are less interested, have low achievement in Science and Mathematics at F3A, lacking self-confidence and low motivation to engage in this field. This has influenced the implementation of the policy to achieve 60 per cent student enrolment in STEM.

School Factors

Apart from student factors, the interviews also found that the achievement of the 60:40 policy was also influenced by teachers and laboratory infrastructure which are sub-factors to the school factors. The following are some feedback from the respondents:

"....teacher may not good to attract student's interest towards STEM. Besides, teacher's knowledge about STEM is not up to date ..."(P3)

"...the main thing is our infrastructure incomplete. If you want to see you can see my school's lab, it is very poor..."(P7)

"Infrastructure and facilities for Science learning are limited, especially incomplete laboratories." (P8)

P3 respondents stated that the knowledge of STEM teachers who are not up-to-date is one of the factors that have caused the 60:40 policy to be unreachable. Teachers who do not have the latest knowledge and information regarding STEM are believed to be unable to create fun teaching and learning sessions (Phang, Abu, Ali & Salleh, 2014). In addition, teachers will also face difficulties in creating an exploratory and creative teaching and learning environment (Loyen, Rikers & Schmidt, 2006; Susanto, 2013). Hence, this will cause students to lose interest in the subject (Susanto, 2013).

Apart from the sub-factors of the teacher, the respondents also argued that the inadequacy of this policy was also influenced by the science labs infrastructure. According to respondents P7 and P8, the laboratory at school was in an incomplete state and has limited infrastructure. Due to the limitation in the science lab infrastructure, exploratory learning cannot be fully implemented (Fulton & Britton, 2010). Therefore, student's curiosity will not sprout, and students' interest in STEM is also lacking (Gafoor & Narayan, 2012; Eppley, 2017). Finally, the placement of students as much as 60 per cent in STEM as intended by 60:40 cannot be realised.

Parent Factors

The next findings have identified parent's factors also influence the implementation of the 60:40 policy. The following is an interview quoted by the respondents.

"Next is the parents ... parents who do not encourage students to go STEM because of the difficulties to get a job in this field." (P1)

"There are family factors to, for example, if you're a doctor, they want their children to be a doctor. But there is also a family that thinks in terms of salary, why need to be a doctor, if the accountant salary is high." (P3)

".... the influence of parents, they said doctors and engineer is not a good career when compared to a businessman, because doctors and engineers may be employees by the businessman when he opens a company, besides to be entrepreneurs do not necessarily have medical qualifications and engineering." (P6)

Based on previous studies, parental support will increase self-esteem (Turner 2010), interest (Malaysia Ministry of Education, 2013) and motivation (Beedee et al., 2011; Leaper et al., 2012). However, interviews show that less parents encourage students to choose STEM. This is as stated by respondents P1, P3 and P6, the lack of parental support is due to the parent's perception that job opportunities in the STEM field are limited and the benefits are not lucrative. Therefore, parents do not support and encourage students to further their studies in this field. A recent study by Hassan et al. (2013) also stated that parents who do not have academic backgrounds with STEM less encourage their children to study this field. This may be because parents are less likely to have information related to STEM and career opportunities (Ryan, Joshua, Kristin & Chris, 2011). Not only that, parents are also found to have a low awareness of STEM (Malaysia Ministry of Education, 2012) which has resulted to the lack of parental support for this field. This situation led students not to choose the STEM field for further studies and because of this the 60:40 policy could not be reached. Because of that, parents should give support to their children in order to increase student's interest towards STEM field.

Administrator Factors

In addition to the above factors, the respondents also stated that the academic background and administrator's knowledge have also influenced the implementation of the 60:40 policy. Here are some of the relevant interview quotes.

"The principals who are not backgrounds from this field most likely has no motivation to encourage his students to take STEM." (P2)

"Most principals support it. But I can tell in terms of data, fewer principals and school's administration are from Science or Mathematical background, even technology, I think this also an important factor that contributes to the target of the policy." (P4)

"Like principals, though they are not Scientists. But they can encourage students to Mathematics and Science. That's not an issue. But if the principal among Mathematics and Science background is a bonus. Easier...He knows what to do and how to do in order to achieve the policy target." (P7)

Based on interviews, respondents have stated that principals who have an academic background in Science, Mathematics and technology are more supportive of the implementation of this policy. This is because the principal knows what needs to be done to attract students to choose the STEM field as stated by respondent P7. This situation as stated by Derue, Nahrgang, Wellman & Humphrey (2011), emphasised on the background of principals such as academic approval affects the administration. This statement is consistent with the findings of Shen, Leslie & Xin Ma (2012) that there is a significant relationship between the administrator's background and school achievement. In this case, achievement is associated with an increase in the number of students in the STEM field by 60:40 as intended.

In addition, according to respondent P2, principals who do not have an academic background in STEM are less motivated to encourage students to choose the STEM field. However, respondent P4 argued that most principals support the policy, but if principals have the qualifications in Science and Mathematics, then the principals will strive further to increase student participation in the STEM field. This is because when the principals know and understand the matter, it is easier to achieve the goals (Reinhartz & Beach, 2004; Ayob Jantan, 2005). Hence, principals can give a good explanation to all schools, students and staff (Hussien, 2008). Then, the goal of the 60:40 policy will be supported and is achievable at school (Lee & Shukri, 2016).

Discussion

Based on these findings, it can be concluded that the factors that influence the achievement of 60:40 policy can be divided into four main factors, namely student factors, school factors, parent factors and administrator factors. The results of the interview analysis found that the relevant factors were interconnected with each other in determining the achievement of 60:40 policy. The following figure summarize the critical factors that influence the implementation of this policy.

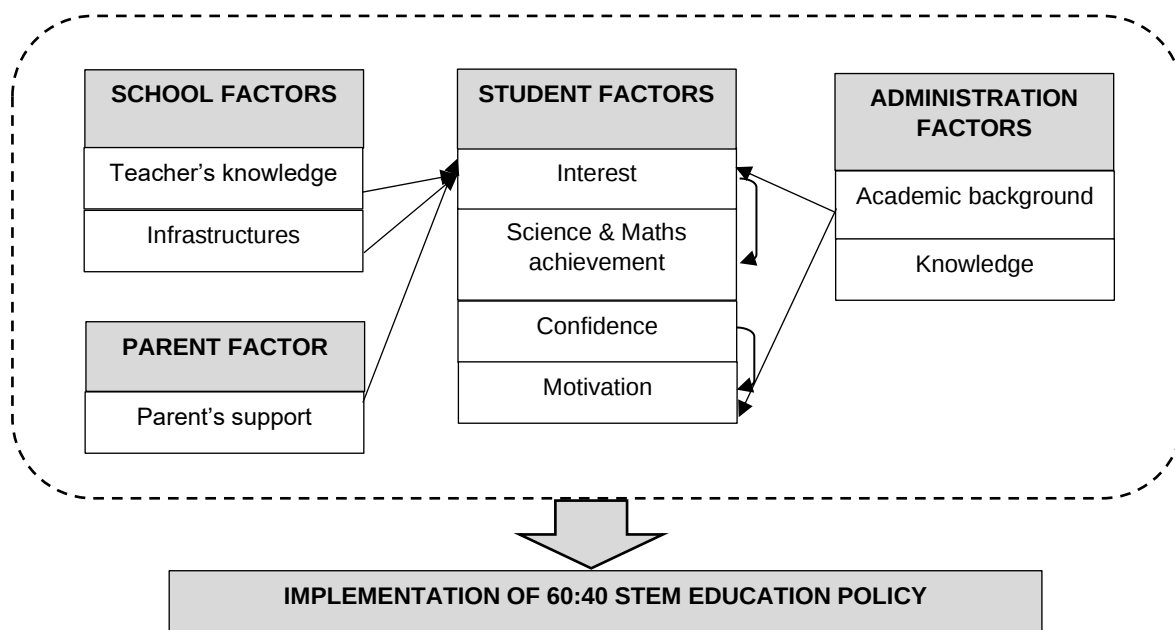


Figure 1: Critical Factors that Influence the Implementation 60:40 STEM Education Policy

Based on the figure 1, the student's factors that have been identified are interest, achievement of Science and Mathematics, self-confidence and motivation. The student's factor was found to be the main factor that influenced the achievement of this policy. Students self-factor according to Yazilatas et al. (2013) is a psychological factor found in an individual. It is an individual's personal internal factor that encourages him to do something (Halpern, 2007; Ing, 2013). Based on previous studies, interest is a key factor in determining student's inclinations towards STEM (Krapp, 2003; Katz, Kanat-Maymon & Bereby-Meyer, 2006; Griffith, 2010; Morgan et al., 2016). Therefore, schools should have an excellent planning to enhance student's interest towards STEM.

The results also showed that several factors were identified to influence the student's interest in the STEM field. Figure 1 showed that the student's interest is influenced by teachers, laboratory infrastructure, parents and administrators. All these external factors gives a direct impact towards students' tendency to pursue STEM field.

According to previous studies, the elements in the student's factors also influence one another (Yazilatas et al., 2013; Else-Quest, Mineo & Higgins, 2013; Balakrishnan et al., 2015). This situation is in line with the results of the interviews which established that when students have an interest, it will definitely improve their achievement in Science and Mathematics subjects. This is because interest will encourage students to seek good results in the subject (Noor Erma Abu & Leong Kwan Eu, 2014), which is similar to the survey findings. Furthermore, this good achievement will encourage students to choose the STEM field (Xu, 2008; Gafoor & Narayan, 2012; Wang & Degol, 2013; Yatin, S. F. M., Alias, M. N., Awang, N., & Burhanud-din, N. F. 2018; Omar, Rahman, Hamid, 2018). In addition, the interview findings also revealed that student's self-confidence contributes to their motivation towards achieving something as stated by Hackett and Betz (1989) and Bandura (2006). According to Faitar and Faitar (2013), confidence has a strong influence on students who are engaged in the STEM field. Therefore, when students have an interest, they will try harder to improve their achievement

in Science and Mathematics. This condition leads to increased confidence and motivation which will ultimately encourage the student to choose the STEM field. As a result, the target of 60:40 policy will be achieved.

Besides that, teacher's knowledge, laboratory infrastructure and academic background of administrators also affect students' interest. According to Meor Ibrahim and Nurul Amira (2010), teachers are responsible for increasing student's interest in a subject. Since the STEM field is an ever-expanding field with many new findings, teachers need to have the latest STEM knowledge to share with students (Phang et al., 2014). This will create an effective learning environment and attract students to STEM (Susanto, 2013). In addition, student's interest in the STEM field is also influenced by laboratory infrastructure in schools. Complete laboratory conditions can stimulate a student's interest in STEM to grow and increase (Becker & Park, 2011; Bottia, Stearns, Mickelson, Moller & Parker, 2015; Eppley, 2017). This is because a complete laboratory allows teachers to carry out effective teaching and learning and to enable students to actively learn.

Apart from that, the academic background of the administrator also contributes to the interest and innovation of the students. According to interviews, administrators with an academic degree in Science and Mathematics have a better planning on what to do to achieve the 60:40 policy. This is because the administrator can identify the best approach to attract and improve student interest and motivation towards STEM (Bass, 2008). On the other hand, academic background also has an influence on school achievement (Shen et al., 2012) and the effectiveness of the education system (Yusri & Aziz, 2014). Therefore, administrators with academic qualifications in the STEM field are more enthusiastic in achieving the goal of 60:40 policy.

All these critical factors that had been identified in this research should be taken into account when implementing the 60:40 STEM:non-STEM policy. Schools should have a short term and long term planning to ensure that the target of 60 percent of students in the STEM field as intended by this policy can be achieved. The administrators must have their own school's planning based on their student's factors, teacher's knowledge and infrastructures. The most important things, the planning should have an activities or program that can catered student's factor that had been identify in this research. Besides that, the schools should have a planning which pay attention to a parents to ensure parents aware about the important of this policy to be achieved and finally school can get support from them. For and foremost, the administrators must have a better knowledge and skills how to achieved the target of this policy. A knowledge sharing session between administrators with STEM and non-STEM academic background should be carry out to find a best practiced to fulfilled the objective STEM education policy.

Conclusion

This study has explored some of the critical factors that impacted the achievement of the 60:40 policy. As a result of this study, student factors are the main factors contributing to the successful implementation of this policy. Therefore, stakeholders and school administrators need to work together to ensure that the programmes and activities are focused on raising students' interest, confidence, motivation and achievement in Science and Mathematics. At the same time, programmes to increase parental support and teacher knowledge need to be implemented as well. In addition, laboratory infrastructure equipment

also needs to be completed to make teacher teaching more effective. All these factors, parental support, teacher knowledge and infrastructure plays an important role in increasing student interest towards STEM. The findings of this study also found that the administrators' backgrounds also contributed to the policy achievement of 60:40, which has been underestimated by previous studies. Hence, more qualified individuals in the STEM field should be appointed to administer the school. This is because individuals who have qualifications in STEM knows what needs to be done, so that STEM education can be implemented more effectively. This study can be furthered by focusing on the location and type of school. Different locations and types of schools will provide different insights on STEM implementation in these schools.

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