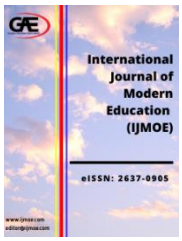

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THE RELATIONSHIP BETWEEN SELF EFFICACY AND MOTIVATION WITH STEM EDUCATION: A SYSTEMATIC LITERATURE REVIEW

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Abstract:

While Malaysia's performance in the international assessment such as TIMSS and PISA are inclined to worry, enrollment of students in the science stream is also decreasing. Even though there are rapid changes made into the curriculum, teaching strategies and assessment method, the quality of Malaysia's education system especially in mathematics have not shown any promising changes. The purpose of this study is to analyze previous studies on the relationship between students' self-efficacy and motivation with STEM education. This systematic review is conducted by qualitatively analyzed 34 articles from Scopus, Google Scholar and MyJurnal using thematic analysis. The result of the analysis is categorized into six themes: non-cognitive factors, pedagogy, STEM intervention programs, social-economic status, teachers' gender, and mathematics curriculum. The result shows that self-efficacy and motivation are highly affected by mathematics achievement. This paper suggesting a rapid study on STEM education at the primary school level so that issues related to mathematics achievement can be solved at an earlier stage.

Keywords:

STEM Education, Self-Efficacy, Self-Concept, Motivation, Mathematics Achievement

Introduction

Recently Science, Technology, Engineering and Mathematics or STEM has becoming one of the most focused issue in education. STEM education being widely promoted at school level in Malaysia when students performance in mathematics and science at international assessment level are underachieve. Whereas the demand of work field with mathematical skills are

increasing, courses at tertiary level involving complex subjects such as mathematics are disfavor among school-leavers (Ayub, Yunus, Mahmud, Salim, & Sulaiman, 2017). This has brought Malaysia to another issue regarding lack of skilled workers in mathematics and science field. Therefore, intervention should have been done starting from school level to overcome current issue regarding decreasing number of students joining science stream classes. This is because decision and after school planning has been done once the students decided to be in any stream during upper secondary level (Stacy, Cartwright, Arwood, Canfield, & Kloos, 2017).

The comparison of mathematics and science achievement can be seen through international assessment report such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Students Assessment (PISA). TIMSS and PISA has become the bench mark among participating countries to evaluate science and mathematics performance of each country. Reports of TIMSS and PISA are also provided other insight information based on conducted questionnaires which are useful for further actions and studies. Based on TIMSS and PISA reports, self-concept and self-efficacy are two dominant factors that affecting students' motivation in mathematics (J. Lee & Stankov, 2018; OECD, 2013; Pitsia, Biggart, & Karakolidis, 2017).

As the rank in TIMSS and PISA indirectly represent the quality of students as well as the quality of mathematics and science education, Malaysia's worrisome rank has urge transformation in national education system to improve for better (Ministry of Education Malaysia 2015, 2018). Unpromising number of students enrol in science stream classes is still one of the main issue in Malaysia. Students reportedly show no interest in mathematics which eventually lead to mathematics anxiety as mathematics is not an enjoyable subject (León, Núñez, & Liew, 2017). Lack of understanding and exposure of mathematics application in daily life has cause students to accept mathematics as a subject that solely learnt for examination purpose. Ministry of Education Malaysia (MOE) therefore take the initiative to integrate STEM in mathematics and science. According to Malaysia Education Blueprint 2013-2025, STEM education has the potential to boost students' interest in learning through hands-on activities.

Self-determination theory by Deci & Ryan (1990) has categorized motivation into intrinsic motivation and extrinsic motivation. Intrinsic motivation gives longer term impact compare to extrinsic motivation as intrinsic motivation are based on students' self-willingness in completing or achieving particular task without any external force or influence. Hence, students' motivation highly correlated with self-belief. Students with high self-efficacy are slightly more motivated and confidence to involve in school task (Cleary, Velardi, & Schnaidman, 2017). In this study, researcher focused on articles related to self-beliefs, motivation and STEM education.

Appearance of new terms in teaching and learning such as digital classroom and 21st century learning shows changes movement in pedagogy is happening. Previous studies shows that technology integrated classroom and students-centred learning contributed to positive effects on students' interest, however are these learning improved students' self-belief and motivation in mathematics? Systematic literature review is a study to gather information systematically and focusing on targeted issues from previous studies to answer researcher particular research questions (Xiao & Watson, 2017). Through systematic literature review, researcher will be able to recognize gaps in the field of study and the needs for further study. This study is driven by

research question: To what extent self-belief and motivation influence students' mathematics achievement?

Methodology

This section will discuss methods of choosing and collecting articles related to the keywords of this study: self-beliefs and motivation in mathematics. The review and analysis of this study were perform systematically at three electronic databases namely Scopus, Google Scholar and MyJurnal. The process of systematic review involved three phases: identification, screening and eligibility which will be discussed further in the next section.

Data Source

Articles selecting is searched in the main database that is Scopus since the quality of articles published in Scopus is guaranteed. Only peer-reviewed articles are published in Scopus. Scopus published wide range of articles from various fields and subscribed as the main database by more than 3000 institutions. Additionally, researcher also conducted articles searching manually at different database such as Google Scholar and MyJurnal for articles related to self-belief and motivation in local context based on the title, abstract and keywords of the articles.

Systematic Review Process

Identification

There are three phases involved in this systematic review that is identification, screening and eligibility in the process of articles selecting at Scopus database. Identification is a process of article searching related to research topic guided by the main keywords. Main keywords were determine accordingly to the preliminary articles read by researcher which related to the research question of this study: To what extend self-belief and motivation influence students' mathematics achievement? The keywords used during identification process are self-determination theory, STEM education, self-efficacy, mathematics achievement and motivation. With this, articles searching at Scopus database is retrieved and only related articles with the keywords are listed. To maximize the article searching, synonyms and related terms to the keywords were identified based on suggestion by Scopus. In addition, the search string is carefully developed using Boolen operators "or" to broaden article searching and "and" to specify article searching based on the keywords only. Phrase searching by putting "" to the keyword is also applied to the search string. Finally, to diverse article searching, truncation technique using "*" is also applied (e.g.: mathematics achievement*). A total of 867 articles were identified through identification searching. While for Google Scholar and MyJurnal database, manual searching was applied using handpicking technique based on the same main keywords. Researcher managed to identify 16 more articles related to research question which bring up the sum of 883 articles at this phase.

Screening

At Scopus database, criteria of identified articles can further be narrowed down based on criteria set by researcher through screening. At this phase, process of include and exclude articles are automatically done by the database. This study only focused on articles that published between the years 2017-2019. Only recent three years articles focused by researcher as this paper meant to study the latest trend in mathematics and STEM education. Furthermore, 2017 was the year when Secondary School Standard Curriculum or KSSM was first implemented in secondary school. Another criteria is to only include articles in English. To ensure only primary sources include in the list, documents such as books chapter, proceeding

papers and book series are excluded from the searching. Only articles from social, mathematics and psychology field are included. Based on the mentioned criteria, a total of 670 articles were excluded after screening process.

Eligibility

Up until this phase, a total of 213 articles were shortlisted for eligibility process. Eligibility process is a manual procedure done by researcher to identify into details whether all listed articles are about determined keywords. Title, abstract and main part of the articles such as introduction, result and discussion will be scanned into details. Unrelated and inaccessible articles will be excluded. According to Kitchenham & Charters (2007) there is no specific criteria of articles to review as long as the articles are able to satisfy research question of the study. Through this process, 179 articles were excluded which bring to remaining 34 articles to be reviewed in this study (Diagram 1).

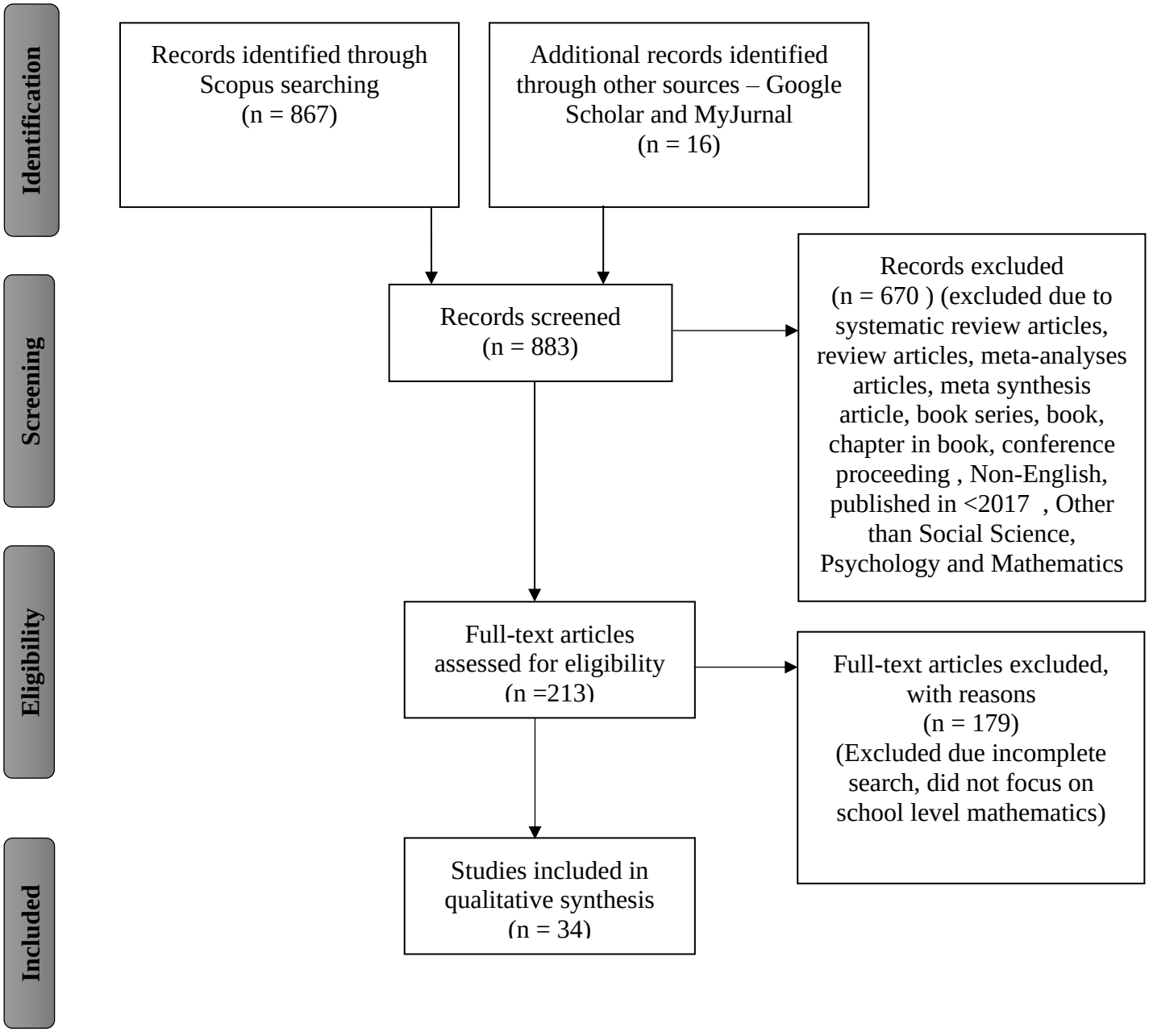

Figure 1: Flow Diagram of the Study

Data Analysis

Shortlisted articles were then downloaded for further details analysis. Qualitative analysis was conducted to all fully assessed articles to ensure issues discussed in all articles are in touch with the purpose of study. Articles were analyzed using basic technique of thematic analysis to identify pattern of previous studies to form main themes of study (Braun & Clarke, 2006) by a thorough analysis of result and discussion of shortlisted articles.

Results

General Findings and Background of The Studies

All articles with consistence findings that self-belief and motivation highly influence students' mathematics achievement. Analysis results has identified a total of six themes from 34 analyzed articles. The six themes are non-cognitive factor, pedagogy, STEM intervention program, socioeconomic status (SES), teachers' gender and curriculum.

Particularly, previous studies generally focused more on correlation between non-cognitive factors with students' achievement, that is a total of 13 studies (Cleary & Kitsantas, 2017; Desoete et al., 2018; Fielding-wells, Brien, & Makar, 2017; Hammoudi, 2018; M. Z. Haron & Ahmad, 2018; Hj. Yahaya, Koay, Maakip, Voo, & Rathakrishnan, 2017; Janet & Hyde, 2016; Kong & Cheung, 2016; J. Lee & Stankov, 2018; Mohammadpour & Shekarchizadeh, 2013; Pitsia et al., 2017; Prast, Weijer-bergsma, Miočević, Evelyn, & Luit, 2018; Schöber, Schütte, Köller, Mcelvany, & Gebauer, 2018). 11 studies focused on teaching and learning or pedagogy (Chen, Star, Dede, & Tutwiler, 2018; Colliver, 2017; El-deghaidy, 2017; Fouze & Amit, 2018; Lazarides & Rubach, 2017; C. W. Lee, Walkowiak, & Nietfeld, 2017; Prast et al., 2018; Proudfoot & Kebritchi, 2017; Sriraman, 2017; Telegina & Drovosekov, 2019; Yang, 2015), five studies about the need of STEM intervention programs (Cleary et al., 2017; Falco, 2019; Mohamad Yusop, Sumari, K. Azeez, Said, & Mohd Jamil, 2015; Tran, 2018; Yusof & Jalil, 2012) and three studies were about students' SES factor (Alordiah, Akpadaka, & Oviogbodu, 2015; H. N. Haron, Kamaruddin, Harun, Abas, & Salim, 2019; Hentges, Galla, & Wang, 2018). Meanwhile, one of the studies' finding was teachers' gender (Hand & Rice, 2017) and one study related to mathematics curriculum (Hannula, 2019).

Even though during screening phase at Scopus database only articles published between 2017-2019 were chosen, manual handpicking of articles at Google Scholar and MyJurnal however have no particular publication year setting. Therefore, analyzed articles in this study are range from the year 2012 until 2019. Four articles were published in 2019 (Falco, 2019; Hannula, 2019; H. N. Haron et al., 2019; Telegina & Drovosekov, 2019), 11 articles published in 2018 (Chen et al., 2018; Desoete et al., 2018; Fouze & Amit, 2018; Hammoudi, 2018; M. Z. Haron & Ahmad, 2018; Hentges et al., 2018; J. Lee & Stankov, 2018; Prast et al., 2018; Schöber et al., 2018; Tran, 2018) and 12 articles published in 2017 (Cleary & Kitsantas, 2017; Cleary et al., 2017; Colliver, 2017; El-deghaidy, 2017; Fielding-wells et al., 2017; Hand & Rice, 2017; Hj. Yahaya et al., 2017; Lazarides & Rubach, 2017; C. W. Lee et al., 2017; Pitsia et al., 2017; Proudfoot & Kebritchi, 2017; Sriraman, 2017). Other than that, two articles published in 2016 (Janet & Hyde, 2016; Kong & Cheung, 2016), three articles in 2015 (Alordiah et al., 2015; Mohamad Yusop et al., 2015; Yang, 2015) and 2013 (Mohammadpour & Shekarchizadeh, 2013) as well as 2012 (Yusof & Jalil, 2012) with one article published respectively.

Main Findings of The Studies

In this section, findings of this study will be discussed mainly into six themes, namely non-cognitive factor, pedagogy, STEM intervention program, socioeconomic status (SES), teachers' gender and curriculum

Non-Cognitive Factor

Self-efficacy and self-concept are two non-cognitive factors dominant in previous studies of factors that influence students' mathematics achievement (J. Lee & Stankov, 2018; Pitsia et al., 2017). The correlation of self-efficacy and self-concept under the domain of self-beliefs (J. Lee & Stankov, 2018) with mathematics achievement were consistent in every study. Despite performance or location of schools, self-beliefs is the main predictor of students' mathematics achievement (Mohammadpour & Shekarchizadeh, 2013; Prast et al., 2018). Students' self-beliefs play vital roles to encourage themselves to be motivated and strive for better achievement in mathematics (Cleary & Kitsantas, 2017; Hammoudi, 2018; Janet & Hyde, 2016; Kong & Cheung, 2016). Students with high self-beliefs tend to be an active leaner during lesson because they are slightly more confidence to get involved in teaching and learning activities (Fielding-wells et al., 2017). For long term effect, higher self-beliefs students may later on become high-skills and independent workers (M. Z. Haron & Ahmad, 2018). This indirectly tackle another national issue regarding high unemployment rates among graduates in Malaysia. Ironically, Malaysia is highly relied on foreign workers in certain industry whereas unemployment rate in Malaysia is worrisome (Jaafar & Maki, 2017).

Pedagogy

Pedagogy or teaching and learning method is one of the main discussed issue when it comes to self-beliefs and motivation in students' mathematics achievement. One of the major changes in Malaysia education system involving pedagogy when teachers are encouraged to shift from teacher-centred to students-centred learning (Ministry of Education Malaysia, 2012). Students-centred learning gives more freedom for students to get involved in the lesson. Active lesson boost students' interest and motivation in learning mathematics (Fouze & Amit, 2018; Proudfoot & Kebritchi, 2017; Sriraman, 2017; Telegina & Drovosekov, 2019). However, teachers should have an effective class controlled skill (Prast et al., 2018) and able to give clear instruction for class activities (Lazarides & Rubach, 2017) so that objectives of the lesson can be achieved. Usage of simple and informal language are also affecting students' interest in learning mathematics (Colliver, 2017; Lazarides & Rubach, 2017). Recently, implementation of technology in teaching and learning is raising with positive outcomes in terms of students motivation (Proudfoot & Kebritchi, 2017). However, the effect is a short terms effect. Even so, teachers should be given proper training from time to time to improve their pedagogy especially in methods to implement a good and effective pedagogy (El-deghaidy, 2017).

STEM Intervention Program

Intervention programs in school to nurture students' interest in STEM related field should be done not only by particular teachers, but an effort should be given by all parties involving school administrator and counselor (Mohamad Yusop et al., 2015; Yusof & Jalil, 2012). Programs related to STEM education should undergo proper planning considering maximizing impact of the program so that the aim to increase students' interest and motivation can be achieved. To nurture students' interest and motivation in STEM education as early as possible, proper planning and implementation are essential.

Socioeconomical Status (SES)

Students' SES is also contribute to their interest and motivation in learning mathematics. Even though SES is not the main factor of students lose interest in mathematics (Hentges et al., 2018), students in rural school are not into choosing STEM related field after school. Students from rural school feels STEM education and their daily life is not relatable (H. N. Haron et al., 2019). Few factors contributed to the gap of STEM acceptance between rural and urban school in Malaysia is lack of meaningful exposure of STEM field and less support from parents (Hj. Yahaya et al., 2017) which causes to students from SES challenging background to be left behind compare to students from urban school (Alordiah et al., 2015).

Teachers' Gender

Involvement of students based on gender are imbalanced when female students are reported to less participate in STEM field compare to male students. Interestingly, teachers' gender in teaching mathematics and science do contributed to students' gender to involve in STEM field (Hand & Rice, 2017).

Mathematics' Curriculum

Mathematics is a complex subject where methods of delivering the lesson impacts students' interest in mathematics. Attention should be given to early education curriculum when introducing mathematics to children. Introducing complex mathematics to children will increase children anxiety in mathematics (Hannula, 2019). This will eventually cause negative acceptance of children towards mathematics and worsen when the children entering secondary school level.

Discussion

Self-beliefs play an important role to increase students' motivation in mathematics. Studies have been conducted in proving relationship between self-beliefs and motivation with mathematics achievement, yet the number of studies on best pedagogy approach to support self-belief is still limited. Special program held by concerned parties to boost students' self-beliefs are necessary in helping school teachers to improve teaching and learning methods. Recently, researchers from psychology and mathematics field are actively study on grit, another variable that believe to have greater impact in boosting students' interest and motivation for long term (Al-Mutawah, Moosa, & Fateel, 2018; A. Duckworth & Gross, 2014; A. L. Duckworth, Peterson, Matthews, & Kelly, 2007; Reraki, Celik, & Saricam, 2015). Longitudinal studies on non-cognitive factors are recommended to get details understanding and ideas to implement better approaches in order to shape students' mathematics achievement (Hand & Rice, 2017; Pitsia et al., 2017).

Pattern of previous studies are focusing more on pedagogy to attract students' interest to choose STEM related field of work as a career. Technology integrated pedagogy gives positive impact on students' interest in improving students' engagement during the lesson. Student-centered approaches such as inquiry learning established by teachers for impacting students' behaviour positively. However, according previous studies, teachers are still struggling in conducting proper students-centre pedagogy. Teachers are demanding for more training on pedagogy courses from the expert rather than one-shot training before they can confidently implement in their lesson. For example, responses of teachers in questionnaire after curriculum related to course of study, intervention action must be taken for any arise issues based on the response.
Interest in mathematics must be nurture since young. Children show positive attitude in mathematics when mathematics is introduced indirectly through games. More attention should be given in designing suitable approaches in introducing mathematics to young children.

Informal approaches are favourable compare to formal education which may cause to lack of interest among children to learn mathematics. The new curriculum in primary school, Primary School Standard Curriculum or KSSR has been fully implemented in 2016. Further studies on issues and challenges in implementation KSSR are in need. Students form rural school basically are less competitive compare to urban school students. The implementation of new curriculum with emphasis more in higher thinking skills may result in wider gap between rural and urban school students' performance. Collaboration with non-government organization in rural school are urged in promoting STEM education related programs as to balance the potential of rural and urban school students.

Conclusion and Recommendations For Future Research

The results of this study shows the importance of students' self-belief so that students will be motivated intrinsically in order to strive for better achievement in mathematics. Teachers' pedagogy method as extrinsic support is also essential to balance students' motivation. A well-organized student-centred lesson will create meaningful lesson. Students can actively participate in lesson's activities while the objective of the lesson are also achieved. This study suggests that there is a need to examine daily lesson plan writing. Other than training and courses related to STEM education pedagogy, daily lesson plan writing is as important as exposure to different types of pedagogy approaches. Influence of teachers' gender is also an interesting topic to study. Until 2018, statistics reports that in both primary and secondary school in Malaysia, only 29.6% are male teachers. (Ministry of Education Malaysia, 2018). Based on this systematic review, efforts in enhance the quality of education is more than just upgrading the curriculum and assessment approaches. Continuous research in different areas are recommended for periodically improvement. Changes is a good thing if it is done systematically. Teachers in Malaysia are encouraged to made action research into practice to improve pedagogy practice from time to time.

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