An Analysis of Knowledge in STEM: Solving Algebraic Problems

Teoh Sian Hoon[1]*, Parmjit Singh[2], Cheong Tau Han[3], NurulAkmal Md Nasir[4], Nor Syazwani Binti Mohd Rasid[5], Nurain Binti Zainal[6]

[1,2,3,4,5,6]Faculty of Education, Universiti Teknologi MARA Malaysia
teohsian@salam.uitm.edu.my
*Corresponding Author

https://doi.org/10.24191/ajue.v16i2.10304

Received: 2 September 2018
Accepted: 28 April 2019
Date of online publication: 30 July 2020
Published:30 July 2020

Abstract: This study was conducted to assess the students' level of abilities in solving algebraic word problems which is a main component in Science, Technology, Engineering and Mathematics (STEM). It also aims to determine the students' difficulties in solving these problems by using Newman's Model of Error Analysis (NMEA). Furthermore, this study was conducted to investigate the attitudes of undergraduate students towards STEM and its relationship to the achievement of the test. The instruments are a test on algebraic problems and a set of questionnaire on attitudes towards STEM. The test which was validated by an expert from a university was adopted and adapted from a problem solving source. The test contained questions from one of the main areas of algebra which focused on two parts namely algebraic knowledge (AK) and algebraic knowledge in the context of science (AKCS). There were a total of 63 undergraduate mathematics education students who took part in this study. This study was carried out using the mixed-methods qualitative approach. The result showed that the majority of the students have a low level of algebraic knowledge as well as algebraic knowledge in the context of science. For the attitude towards STEM, findings displayed that the majority of the students were interested and gave positive attitude towards STEM.

Keywords*:* algebraic knowledge (AK), algebraic knowledge in the context of science (AKCS), Newman's Model of Error Analysis (NMEA), attitudes towards STEM

1. Introduction

Algebraic knowledge is introduced at the primary school level where pupils are introduced to the operations of numbers. However, algebraic knowledge is formerly applied when the students are in Form One of their secondary education. Mathematics curriculum contents include the basic primary school algebraic knowledge. Şengül and Erdoğan (2014) emphasized that learning algebra is crucial for having a strong basic understanding of mathematics. The importance of learning algebra using different methods may help to develop students' strategies and algebraic abilities. Hacker (2012) highlighted that there is a certain percentage of entry-level workers who need to be proficient in algebra, hence it is hoped that more graduates are equipped with STEM knowledge and other strong basic numerical skills (e.g. decimals, ratios, estimating) which will enable them to be successful in fields like engineering.

Mathematics students' interests in STEM are measured through algebraic assessment (Love, Hodge, Grandgenett & Swift, 2014). There are two ways to determine if students are good in mathematics: students who score high marks and have high achievements in a test, and those who are able to apply Mathematics in STEM. Nevertheless, students may display different attitudes in both aspects of learning Mathematics. Many of them have groomed the thoughts and attitude that they need high abilities to achieve good results in Mathematics and Science (The Royal Society, 2014). However, studies on the impact of attitude towards learning Mathematics and Science in Finland, South Korea and Canada showed that perseverance is the key to achieving better results in Mathematics tests (Hacker, 2012).

In STEM education, students need to apply knowledge integrated from Science, Mathematics, Engineering and Technology. In order to meet the demands of STEM, ideally students need to have been exposed to knowledge related to STEM from a young age. However in Malaysia, students who get to choose between science or arts subjects tend to choose the latter. Only about 20% to 40% register for the science stream where STEM subjects are offered. In a survey on barriers to successful implementation of STEM, Ejiwale (2013) revealed that in both Mathematics and Science, the majority of secondary school students who faced difficulties in STEM was due to lack of a solid foundation in basic skills such as algebra. Moreover, demographic factors on learning algebra has also shown that gender disparities in STEM occurred because female students were less likely to pursue STEM (Tyson, Lee, Borman & Hanson, 2007). However, past studies have not fully explained students' attitudes in learning algebra in relation to STEM (Love, Hodge, Grandgenett & Swift, 2014). Hence, this study aims to investigate the influence of students' basic algebraic knowledge and attitudes in STEM.

2. Literature Review

Many educators have highlighted the difficulties of learning algebra. According to Jupri, Drijvers and van den Heuvel-Panhuizen (2014), many students find it difficult to master the subject while teachers themselves may find it difficult to teach it, especially when it is not linked to Mathematics that students had already learned (Chow, 2011). This is not surprising as the general reason why students detest algebra is because of the numerous terms and formulae that try to memorise instead of understanding the concepts.

At the university level, common topics include elementary linear algebra subject that comprises matrices, system of linear equations, determinants, vector spaces, linear transformations, eigenvalues and eigenvectors. For instance, Hoon, Singh and Halim (2018) discovered that the topic of function was a "building block" for students to understand more complex topics of Mathematics but students found the topic difficult to grasp. Egodawatte (2009) highlighted that students' negative perceptions of learning algebra too need to be corrected; the negative perception is attributed to the basic differences between algebra and arithmetic. At the tertiary level, undergraduate students also do not meet a satisfying level of algebra knowledge, i.e. fundamental algebra operation skills, and thus, often fail to perform well in assessments. This is worrying as 35% of college students fail their algebra examination (Islip, 2010). Students' lackluster performance and poor skills has implications on STEM.

STEM education, although has been established for decades rooting in engineering, is still poorly understood (Herschbach, 2011; White, 2014). Only 42% of middle school students choose Science as their major, including vocational and technical programs (Shahali, Ismail & Halim, 2017). With more recent emphasis on individual development and 21st century education, STEM has been touted as an important area for nation building. However, there seems to be a lack of emphasis on students, educators and practitioners in STEM fields (Gerlach, 2012). Results of Trends in International Mathematics and Science Study (TIMSS) and PISA in Malaysia is not encouraging as Malaysia is placed at the bottom two-third of the result. Furthermore, the development of STEM should be in tandem with Social Studies and Humanities (Bahrum, Wahid & Ibrahim, 2017) as they need skills like communication, negotiation and problem-solving strategies at the workplace. These strategies are usually observed and evaluated with Newman procedures which also covers skills like reading, comprehension, transformation, process skill and encoding in solving mathematics problems (Rohmah & Sutiarso, 2018). Hence it is vital to understand student attitude as a starting point to address poor performance and interest in STEM subjects.

3. Methodology

This research employed a survey case study. It focused on first semester mathematics education students in a public university in Malaysia in order to explain their algebraic problem-solving skills, i.e. algebraic knowledge and algebraic knowledge, in the context of science. Hence, an intrinsic case study for the explanatory purpose using descriptive and correlational method was employed. Three research questions were posed: (1) What is the students' level of achievement in the two tests?, (2) What are the students' attitudes towards STEM?, and (3) Is there any relationship between the achievement in algebraic knowledge, algebraic knowledge in context of science and attitudes towards mathematics?

A survey instrument was employed to investigate the students' attitudes towards Mathematics, Sciences, Technology and Engineering as well as 21st century skills. Newman's Model of Error Analysis (NMEA) was employed as it covered students' abilities in solving mathematical problems in terms of errors of reading, comprehension, transformation, process skill and encoding. The instruments for the quantitative method were two tests and a questionnaire. The test consisted of 12 algebraic expression word problems that involved AK and AKCS. The items were adapted from Parmjit (2009). Table 1 below shows the number of items contained in the two tests.

Table 1 Items distribution according to subject

Subject	Item
Algebraic knowledge	1, 2, 3, 4, 5, 11, 12
Algebraic knowledge in context of science	6, 7, 8, 9, 10

The attitude questionnaire consisted of 37 items designed by McKenna (2016) that involved Mathematics, Science, Engineering, and 21st century skills related to STEM education. The items were measured in terms of 5 scales namely '1' – strongly disagree, '2' – disagree, '3' mixed feeling, '4' – agree and '5' – strongly agree. The table below provides the number of items for the different aspects of STEM. Table 2 shows the distribution of the items.

Table 2 Item distribution according to subject in STEM

Aspect of STEM	Item
Mathematics	1, 2, 3, 4, 5, 6, 7, 8
Science	9, 10, 11, 12, 13, 14, 15, 16, 17
Engineers and Technology	18, 19, 20, 21, 22, 23, 24, 25, 26
21st Century Skills	27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37

For the validity of the analysis, several content experts were consulted to verify the items in the test instrument. For the test, the value of coefficient of Conbach's alpha is 0.743; for the questionnaire, the coefficient of Cronbach's Alpha is 0.566. In the data analysis, the students' test results were presented as scores and percentages. The achievement was discussed according to the students' Additional Mathematics- 'high achiever' for students who scored 'A' or 'A+' and 'low achiever' for the rest during *Sijil Pelajaran Malaysia (SPM).* Besides the quantitative data, qualitative data was also obtained from an interview session to determine the level of knowledge in algebra and knowledge of algebra with Science in solving algebraic word problem questions.

4. Result

The results of the study are reported according to the research questions in this section. The first research question is "What is the students' level of achievement in the two tests?" and the results are presented in Table 3. It shows the students' level of achievement in algebraic knowledge and algebraic knowledge in the context of Science. Comparatively, the students scored a higher percentage of the total mark in algebraic knowledge (AK) than algebraic knowledge in the context of Science (AKCS). The result showed that 40 out of 63 students have a low level of algebraic knowledge (21 % of the total; total marks=24) and algebraic knowledge in the context of science (15% of the total; total marks = 14).

Table 3 Descriptive statistics for algebraic knowledge

	Mean of the total mark	Std. Deviation
Algebraic knowledge	5.03 (21 % of the total; total mark=24)	4.494
Algebraic knowledge in context of science	2.11 (15% of the total; total mark = 14)	2.869
Total (I+II)	7.14 (19% of the total, total mark=38)	6.846

The following table (Table 4) shows the students' achievements in the two tests for the different groups of students (SPM Additional Mathematics 'A' and above, and lower than 'A'). The number of students who scored 'A' and above in SPM Additional Mathematics (high achiever) is 23. There are 40 students who scored lower than grade 'A' (low achiever). The following table shows that the high achievers scored an overall of 26% compared to 9% among the low achievers.

Table 4 Descriptive statistics for algebraic knowledge for the two grades

	Mean of the total mark		Std. Deviation	
	SPM (A & Above)/ 23 high achievers	SPM (lower than A)/ 40 low achievers	SPM (A & Above)/ 23 high achievers	SPM (lower than A)/ 40 low achievers
Algebraic knowledge	6.91(29%)	3.95(16%)	6.119	2.773
Algebraic knowledge in context of science	2.96 (21%)	1.63(12%)	3.735	2.133
Total (I+II)	9.87 (26%)	3.36(9%)	9.517	4.063

An analysis of the students' understanding of solving algebraic problems was conducted based on NMEA. Sample of analysis from three students are presented below.

> A father is now 5 times as old as his son. In 15 years, he will be only twice as old as his son. How old are they now?

Student 1

R Please read the question to me. If you don't know a word, leave it out.
S1 (reading)
R Tell me what the question is asking you to do.
S1 The question wants me to calculate the age of the son before and the age of the son and the father after 15 years.
R What are the important key points in the question? Please highlight.
S1 The father is now 5 times as old as his son and in 15 years it will only be twice.
R Tell me how you are going to find the answer.
S1 By calculation (laughing).
R Show me what to do to get the answer. "Talk aloud" as you do it, so that I can understand how you are thinking.
S1 The father now is 5 times as old as his son and in 15 years it will only be twice as for now the age for his son is x and father is 5x because it says 5 times. We will add up to 15 years so 5x+15 = x + 15. In 15 years, it will be twice so the age of son will be times by 2.

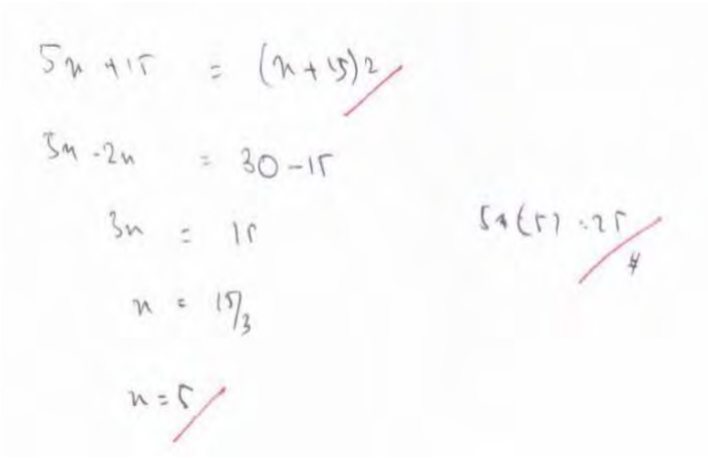

Fig 1 *Solution S1 for question 1*

In solving the problem in Figure 1, the student has shown his conceptual understanding by dealing with the use of operators and writing the equations based on relationship. On the use of operators, the statement of 5 times is written as ‘5 × the son’s age’ and statement of ‘in 15 years’ is written as ‘+15’, finally twice is written as ‘ × 2 to the age of son after 15 years’.

Student 2

R Please read the question to me. If you don’t know a word, leave it out.

S2 (reading)

R Tell me what the question is asking you to do.

S2 The question is asking both the father’s age and his son’s age.

R What are the important key points in this question? Please highlight.

S2 Father is 5 times old as his son. In 15 years, father is twice as old as his son.

R Tell me how you are going to find the answer.

S2 Denote *x* for age of son and add to 15 and equals it to 2*x*.

R Show me what to do to get the answer. “Talk aloud” as you do it, so that I can understand how you are thinking.

S2 15+x equal to 2x. So we find the x. The age for his son is 15 years old and father is 30 years old.

R Now, write down your answer to the question.

S2 (showed her answer)

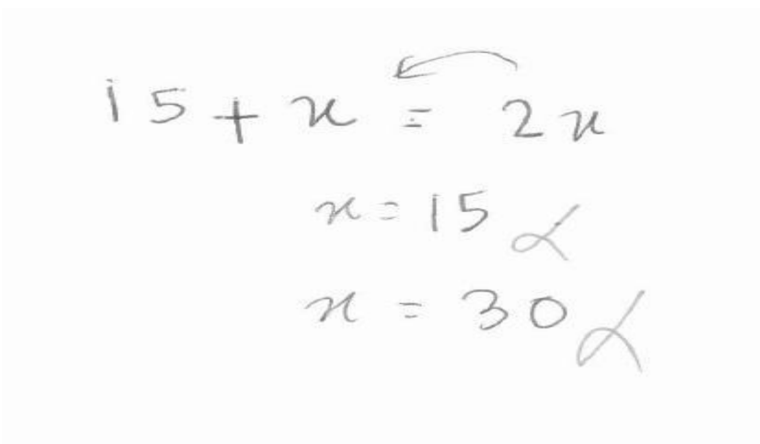

Fig 2 Solution S2 for question 1

The above equation displayed that the information given was not fully transferred into a complete relationship. There were some mistakes in the steps of transformation. The knowledge was not fully transformed into the equation. The knowledge transformation in this problem requires reasoning on (1) the current age namely when ‘x’ is the age of son, the age of father is ‘5x’, (2) the age after 15 years, separately the age of father is ‘5x + 15’ and the age of son is ‘x + 15’, but this time the relationship is ‘5x+15 = 2 times of (x+15)’.

Student 3

R Please read the question to me. If you don’t know a word, leave it out.
S3 (reading)
R Tell me what the question is asking you to do.
S3 This boy’s father is 5 years older as his son. In 15 years, his father is twice old as his son. How old are father and son?
R What are the important key points in this question? Please highlight.
S3 Father is 5 times old as his son. In 15 years, he is only twice as old as his son.
R Tell me how you are going to find the answer.
S3 Let son as x. Father is 5x. 2 times 5x. (laughing).
R Show me what to do to get the answer. “Talk aloud” as you do it, so that I can understand how you are thinking.
S3 Father’s age adds 15 equals to 2x. I guess so.
R Now, write down your answer to the question.
S3 (shows his answer)

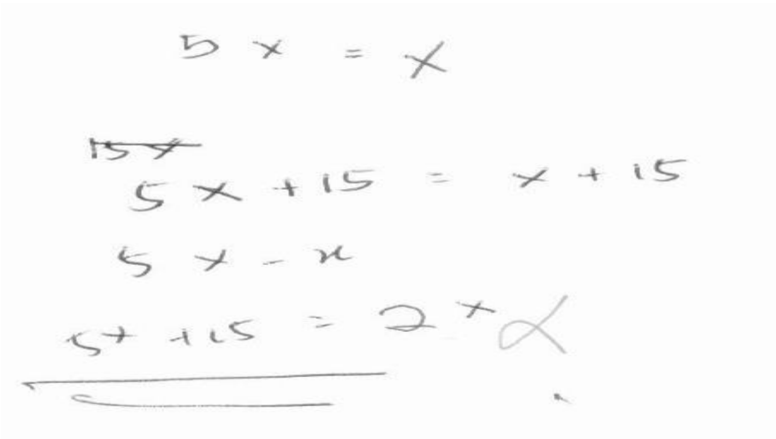

Fig 3 Solution S3 for question 1

The above solutions illustrated that the relationship of the ages was not completely indicated. The final relationship, namely 2 times of the son’s age, was not shown in the solution. In addition, the relationship 5 x = x was wrongly presented. The mistake of 5x = x was shown. In fact, 5x not being equal to x should have been clearly understood. The results revealed that the students did not show their understanding in transforming completely the information provided. The failure of transformation was caused by (1) failure to provide reasoning on the age in the time given, (2) failure to indicate the relationship 5x and x where the relationship between 5x and x appears after fifteen years (means adding 15) with the relationship 2 times of the son’s age after 15 years.

The second research question was “What are the students’ attitudes towards STEM?”. Table 5 shows the mean score of undergraduate students’ attitudes towards STEM overall. The mean score for total attitudes towards STEM overall is 3.37 with standard deviation 0.370. Thus, on the average, the students had positive attitudes towards STEM.

Table 5 Mean score of Undergraduate Students' Attitudes towards STEM as Overall

	N	Mean	Std. Deviation
Mean Attitude Overall	63	3.37	.370
Valid N (listwise)	63		

Table 6 shows that the high achievers and low achievers rated their attitude towards STEM averagely close to each other with mean (high achiever)=3.39 (standard deviation=0.358) and mean (low achiever)=3.36 (standard deviation=0.381) respectively.

Table 6 Mean score of Undergraduate Students' Attitudes towards STEM for the two grades

	N	Mean	Std. Deviation
Mean Attitude Overall (high achievers)	23	3.39	.358
Mean Attitude Overall (high achievers)	40	3.36	.381

The third research question was **"**Is there any relationship between the achievement in algebraic knowledge, algebraic knowledge in context of science and attitudes towards mathematics?".
Table 7 shows:

(1) There is a significant relationship between students' level of achievement in algebraic knowledge and algebraic knowledge in context of science with r = 0.715, p<0.05.
(2) There is a mild significant relationship between students' level of achievement in algebraic knowledge and attitude towards STEM with r = 0.255, p<0.05.
(3) There is a mild significant relationship between students' level of achievement in algebraic knowledge in context of science and attitude towards STEM with r = 0.255, p<0.05.
(4) There is a mild significant relationship between students' level of achievement in algebraic Problem (overall) and attitude towards STEM with r = 0.274, p<0.05.

Table 7 Correlation among Algebraic Problems (I, II & overall) and Attitude

		Algebraic knowledge	Algebraic knowledge in context of science	Attitude (STEM)
Algebraic knowledge	Pearson Correlation	1	**.715****	**.255***
	Sig. (2-tailed)		**.000**	**.044**
	N	63	**63**	**63**
Algebraic knowledge in context of science	Pearson Correlation		1	**.255***
	Sig. (2-tailed)			**.044**
	N		63	**63**
Algebraic Problem (Overall)	Pearson Correlation			**.274***
	Sig. (2-tailed)			**.030**
	N			**63**

Further analysis was conducted among the SPM Additional Mathematics 'high achiever' and 'low achiever' students. For the high achiever, Table 8 showed:

(1) There is a significant relationship between students' level of achievement in algebraic knowledge and algebraic knowledge in context of science with r = 0.857, p<0.05.
(2) There is no significant relationship between students' level of achievement in algebraic knowledge and attitude towards STEM with r = 0.316, p>0.05.
(3) There is a mild significant relationship between students' level of achievement in algebraic knowledge in context of science and attitude towards STEM with r = 0.441, p<0.035.
(4) There is no significant relationship between students' level of achievement in algebraic Problem (overall) and attitude towards STEM with r = 0.376, p>0.05.

Table 8 Correlation among Algebraic Problems (I, II & overall) and Attitude among the high achievers

		Algebraic knowledge	Algebraic knowledge in context of science	Attitude (STEM)
Algebraic knowledge	Pearson Correlation	1	**.857****	**.316**
	Sig. (2-tailed)		**.000**	**.142**
	N	63	**23**	**23**
Algebraic knowledge in context of science	Pearson Correlation		1	**.441***
	Sig. (2-tailed)			**.035**
	N		63	**23**
Algebraic Problem (Overall)	Pearson Correlation			**.376**
	Sig. (2-tailed)			**.077**
	N			**23**

For the low achiever, Table 9 showed:

(1) There is a significant relationship between students' level of achievement in algebraic knowledge and algebraic knowledge in context of science with r = 0.361, p<0.05.
(2) There is no significant relationship between students' level of achievement in algebraic knowledge and attitude towards STEM since p > 0.05.
(3) There is no significant relationship between students' level of achievement in algebraic knowledge in context of science and attitude towards STEM since p>0.05.
(4) There is no significant relationship between students' level of achievement in algebraic Problem (overall) and attitude towards STEM since p>0.05.

Table 9 Correlation among Algebraic Problems (I, II & overall) and Attitude among the low achievers

		Algebraic knowledge	Algebraic knowledge in context of science	Attitude (STEM)
Algebraic knowledge	Pearson Correlation	1	**.361***	**.233**
	Sig. (2-tailed)		**.022**	**.148**
	N	63	**40**	**40**
Algebraic knowledge in context of science	Pearson Correlation		1	**.099**
	Sig. (2-tailed)			**.542**
	N		63	**40**
Algebraic Problem (Overall)	Pearson Correlation	1		**.211**
	Sig. (2-tailed)			**.191**
	N			**40**

5. Discussion and conclusion

The findings showed that the majority of the students faced problems in the two tests. This indicated that they had low algebraic knowledge. From the interview, only students who managed to use operators and write equations based on relationships successfully solved the algebraic problem. On the other hand, students who faced problems writing the relationship among the variables failed to transform the information. The data revealed that transforming information based on relationships was the main cause of problems in solving the algebraic problems. These results reflected previous studies that a high percentage of students who failed to solve mathematical problems had shown problems in the transformation of the given information (Newman, 1977; Singh, Rahman & Hoon, 2010).

The finding showed relatively positive attitudes towards STEM. Overall, the students had a significant relationship between achievements in algebraic knowledge and algebraic knowledge in the context of science. The relationship in terms of correlation is shown stronger among the high achievers compared to the low achievers. The high achievers showed a significant relationship between their achievement in algebraic knowledge in the context of science and attitude. However, there is no significant relationship between algebraic problem achievement and their attitude. These findings revealed that the overall attitude towards STEM had a mild impact on the algebraic problem achievement. Specifically, the relationship was shown in the high achievers answering algebraic knowledge in the context of science. The low achievers did not show any significant relationship between their achievements in the test and their attitudes; but they only showed a mild significant relationship between the achievement in the two tests. Hence, the students' attitudes towards STEM did not significantly contribute to their achievements in algebraic knowledge.

These findings supported previous studies stating that students will be only interested in STEM if they have a deep understanding of learning contents or knowledge (Hayden, Ouyang, Scinski, Olszewski & Bielefeldt, 2011). Matta, Monterio and Peixoto (2012) found that motivation-related factors are the main predictors of attitude towards Mathematics. In this study, attitude towards STEM also includes attitude towards Mathematics. The motivation-related factors may come from good achievement in Mathematics, hence the high achievers also showed significant relationship between their achievements in the higher levels of Mathematics , i.e. algebraic knowledge in the context of science. On the other hand, it was reported in a previous study that students' attitude is also influenced by their experiences and beliefs (White, Way, Perry & Southwell, 2005). Hence, the findings of this study also reflected that the high achievers may have had strong beliefs in solving problems, which positively affected their attitudes towards learning STEM. In terms of conceptual understanding, all the students faced difficulties in transforming mathematics knowledge with reasoning.

REFERENCES

Bahrum, S., Wahid, N., & Ibrahim, N. (2017). Integration of STEM education in Malaysia and why to STEAM. *International Journal of Academic Research in Business and Social Sciences*, *7*(6), 645-654.

Chow, T. C. F. (2011). *Students' Difficulties, Conceptions and attitudes towards Learning Algebra: An Intervention Study to Improve Teaching and Learning* (Doctoral dissertation, Curtin University).

Egodawatte, G. (2009). Is Algebra really difficult for all students? *Acta Didactica Napocensia*, *2*(4), 101-106.

Ejiwale, J. (2013). Barriers to successful implementation of STEM education. *Journal of Education and Learning. Vol.7* (2) pp. 63-74.

Gerlach, J. (2012). *STEM: Defying a simple definition*. NSTA WebNews Digest-NSTA Reports.

Hacker, A. (28 July, 2012). *Is algebra necessary?* The New York Times, Sunday Review, SR1..

Herschbach, D. R. (2011). The STEM Initiative: Constraints and Challenges. J*ournal of STEM Teacher Education, 48*(1). doi:10.30707/jste48.1herschbach

Hayden, K., Ouyang, Y., Scinski, L., Olszewski, B., & Bielefeldt, T. (2011). Increasing student interest and attitudes in STEM: Professional development and activities to engage and inspire learners. *Contemporary Issues in Technology and Teacher Education*, *11*(1), 47-69.

Islip, E. (1987). *Why Do Students Fail At Algebra?* (Unpublished doctoral dissertation). California State University. doi:http://dspace.calstate.edu/bitstream/handle/10211.9/136/Beth%20Islip%20-%20Revised%20Formatted%20%20Thesis%20%281%29.pdf?sequence=1

Hoon, T. S., Singh, P., & Halim, U. K. A. (2018). Understanding of Function and Quadratic Function among Secondary School Students in Selangor. *Asian Journal of University Education*, *14*(1), 77-88.

Jupri, A., Drijvers, P., & van den Heuvel-Panhuizen, M. (2014). Difficulties in Initial Algebra Learning in Indonesia. *Mathematics Education Research Journal*, *26*(4), 683-710.

Khalil, N. M., & Osman, K. (2017). STEM-21CS Module: Fostering 21st century skills through Integrated STEM. *K-12 STEM Education*, *3*(3), 225-233.

Love, B., Hodge, A., Grandgenett, N., & Swift, A. W. (2014). Student learning and perceptions in a flipped linear algebra course. *International Journal of Mathematical Education in Science and Technology*, *45*(3), 317-324.

Mata, M. D. L., Monteiro, V., & Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *Child development research*, *2012*.

McKenna, Rachel Lynn-Pleis, (2016), *Girls and STEM (Science, Technology, Engineering, and Mathematics) in Catholic Schools: A Mixed Methods Exploration of Interest, Confidence, and Perceptions of STEM Doctoral Dissertations*. 317. https://repository.usfca.edu/diss/317

Newman, M. A. (1977). An Analysis of Sixth-Grade Pupils' Errors on Written Mathematical Tasks. In Clements, M. A. & Ellerton, N. (1996). The Newman Procedure for Analysing ErNewman, M. A.: 1977, 'An analysis of sixth-grade pupils' errors on written mathematical tasks', in M. A. Clements, and J. Foyster (eds.), *Research in Mathematics Education in Australia*, 1977, Melbourne, *1*, 239–258.

Parmjit, S.(2009). *Mathematical Problem Solving for Teenagers*. Primera Publication.

Rohmah, M., & Sutiarso, S. (2018). Analysis problem solving in mathematics using theory Newman. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(2), 671-681.

Shahali, E, H, M., Ismail, I., & Halim, L. (2017). *STEM Education in Malaysia: Policy, trajectories and initiatives in STEM education*. 122-133.

Şengül, S., & Erdoğan, F. (2014). A Study on the elementary students' perceptions of Algebra. *Procedia-Social and Behavioral Sciences, 116*, 3683-3687.

Singh, P., Rahman, A. A., & Hoon, T. S. (2010). The newman procedure for analyzing primary four pupils errors on written mathematical tasks: A Malaysian perspective. *Procedia-Social and Behavioral Sciences*, *8*, 264-271

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk*, *12*(3), 243-270.

The Royal Society (2014). *Vision for science and mathematics education*. London

White, D. W. (2014). What is STEM education and why is it important. *Florida Association of Teacher Educators Journal*, *1*(14), 1-9.

White, A. L., Way, J., Perry, B., & Southwell, B. (2005). Mathematical attitudes, beliefs and achievement in primary pre-service mathematics teacher education. *Mathematics teacher education and development*, *7*, 33-52.