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Gender Difference Influence Students' Performance in Learning Math in Secondary Schools

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ABSTRACT

As mathematics has been viewed for decades as a strereotyped male domain, gender differences in mathematics learning have received strong attention from scholars. This study, therefore, investigates the influences of gender differences on students' performance in learning math in secondary school context. The study used a synthesis research. This method of research is undertaken by synthesizing any relevant studies in order to draw conclusion. Some empirical studies investigating the issues of gender difference and learning match were carefully analyzed and synthesized to draw the links between gender differences and secondary students' academic achievements in learning math. The findings show that male students outperform female students in mathematics learning for three reasons. First, social gender stereotypes about students' math ability may lead students to endorse math-gender stereotype themselves. This kind of stereotype makes male students more confident whereas female students become more anxious. Second, personality and spatial ability, as representors in mentality, have commonly been proven that another reason for the advantage of male students in mathematics education. The last is physical advantages in which current evidences suggest that males are more active in some brain areas which are related to mathematics ability. This essay highly recommends future research focus on physical reasons of gender difference in mathematics learning.

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INTRODUCTION

Mathematics is defined as the foundation of science-related academic performance and predictor on of professional success in science-related fields (Forgasz, Leder, & Tan, 2014). For decades, scholars have been concerned that female and male students perform differently in learning mathematics. These concerns centred on a "gender gap" in mathematical performance, especially in secondary school. The most important relevant finding is Male students can

earn higher scores than female students, As a result of this, the male students have a tendency to easily seek math-related field jobs (Alcock, Attridge, Kenny, & Inglis, 2014). Hence, in this essay, we will argue that boys perform better than girls in mathematics learning, then will explore and critical discuss why. The discussion begins with explaining the background of the issue, and examining three supporting ideas from three different aspects like social-cultural influence, mental advantages and physical advantages.

Firstly, the essay will refer to social-cultural influence as one of the reasons for male perform better in mathematics learning. Based on traditional social culture, some people hold a kind of bias: mathematics is stereotyped as male domains (Lindberg, Hyde, Petersen, & Linn, 2010). Beilock, Gunderson, Ramirez, and Levine (2010) have done a research in several American schools which show hat bias or views of people about doing the math, over and above their practical math ability, can be a hindrance to their math achievement. Then, the essay will discuss that boys have some mental advantages such as spatial ability, which is identified as one of the most useful ability in mathematics learning. A strong relationship between spatial ability and math performance of boys, but not girls has been reported in the literature of Ganley and Vasilyeva (2011). They also reveal that gender differences in spatial ability are consistent with the differential participation of spatial reasoning when solving math problems. Thus, it may lead to corresponding gender differences in mathematical achievements. The third supporting idea is boys have some physical advantages in mathematics learning. According to Keller and Menon (2009), clear gender differences in functional brain activation were found: males showed higher dorsal stream activation in the right intra-parietal sulcus areas, which play an important role in numerical cognition which is known as the basis of mathematics learning.

Despite there are some of the disagreements of the argument above, we can still find some literature and studies to convince and refute these counter-arguments. These will be elaborated in the body section of this essay. Therefore, we will insist the argument that boys perform better as the conclusion.

RESEARCH METHODE

To gather and analyze the data, this research used synthesis research. This method of research is undertaken by synthesizing any relevant studies to make conclusions. In this research, therefore, the actual empirical research investigating the issues of gender difference and learning match were carefully analyzed and synthesized to draw the links between gender differences and secondary students' academic achievements in learning math. The studies

relating to the influences of gender differences on match performance were collected from three main reliable sources that are ERIC Journal, Google Scholar and Scopus. To find relevant studies, the researchers employed the aid of Boolean operators such as AND, OR, and NOT to specify the focus of the search. Also, the specific keywords regarding the notions of gender difference, math, and secondary student were carefully used to collect relevant articles. Only peer-reviewed articles were listed and included in this study.

RESULT AND DISCUSSION

The main argument of this essay is that boys perform better in mathematics learning than girls. An empirical study of Brunner, Krauss, and Kunter (2008) further support the idea which shows that in high school mathematics typically report gender differences in favour of boys. Better performance can be proved from three aspects: better scores on examination, better mental ability and physical advantages. Accordingly, those points will be the supporting ideas to evidence the main argument and they will be examined in detail in this essay.

Social expectations encourage male students earn higher scores in mathematics learning

This essay believes that social expectancies for math competence of students often have gender stereotyped and can influence students' math attitudes and scores. The social expectations and gender bias usually come from teachers (Espinoza, Arêas da Luz Fontes, & Arms-Chavez, 2013) and parents (Tomasetto, Mirisola, Galdi, & Cadinu, 2015).

Firstly, the results of a study (Sarouphim & Chartouny, 2016) depict hat teachers interacted with boys almost double as often as they did with girls (331 and 179 interaction respectively). Students are sensitive to teachers' attitudes and behaviours (Gunderson, Ramirez, Levine, & Beilock, 2011). Thus, female students who had fewer opportunities to interact with their teacher are more likely to hold negative attitudes when teachers consciously or unconsciously show gender partiality in the classroom (Brown, Brown, & Bibby, 2008). These negative math attitudes can hinder female students from performing at their best or performing as like what boys did in mathematics learning (Espinoza et al., 2013). In contrast, the boys who perceived more interaction from teacher are encouraged to practice more in learning process than the girls. As a result, the boys tend to gain higher scores in math examination. (Brown, Brown, & Bibby, 2008)

Secondly, a study from Tomasetto et al., (2015) points that parents as a major environmental influencing element, play an important role in the

development of students' ability to learn in different academic domains including mathematics. More specifically, in a recent American study (Gunderson et al., 2011), scholars proved that in middle school and high school, parents of male students tend to hold the opinion that their child has higher math ability and expect their child to gain higher scores in mathematics tests than parents of female students. When the parents of boys believe tis kind of stereotype, their perspective carries positive attitudes for the math achievement of their sons (Casad et al., 2015). Thus, boys are encouraged to earn higher scores on mathematics tests.

However, some scholars disagree with this opinion. They believe social expectations do not influence mathematics attainment. Some scholars argue that the stereotypes about female inferiority in mathematics are contrary to the scientific data. For example, Else-Quest, Hyde, & Linn, (2010) conducted a meta-analysis found that gender differences in mathematics performance averaged over all samples. Generating the sample of students in secondary schools, the female students scored even higher though by an insignificant amount. Meanwhile, findings from Lindberg et al., (2010) support the view that males and females perform similarly in mathematics. Therefore, Campbell & Alberts, (2009) point out that although both boys and girls in secondary schools perform equally in mathematical tests, parents and teachers nonetheless view boys as performing better at mathematics than girls.

To refute this disagreements, the study focusing on teachers in a secondary school in the United States provides evidence that teachers' attitudes have an effect on female students' math achievements by influencing female students' beliefs about "who is good at math" (Beilock et al., 2010). Another study also confirms the association between female student's beliefs and achievement. For example, Sax et al., (2015) conclude that math self-concept (MSC) refers as an important influence factor of the performance of math fields. They prove that female student underperformed in the math fields generally due to their MSC steadily lower ratings than male students. Also, there is another research (Beilock et al., 2010) which shows that at the beginning of the school year, students' mathematics achievement did not show any difference. But by the school year's end, the more teachers have gender stereotype about math, the more likely girls (but not boys) endorse the same opinion that boys are good at math, and girls are good at reading.

In sum up, these essay is in accord with the argument indicating that boys outperformed girls in mathematics education in secondary school, and social expectations can be one of the reasons. Teachers' interaction and parents' attitudes encourage male students to perform better than female students in

mathematics. Although some scholars argue that gender difference in mathematics learning is just stereotype and have no influence on math achievements, we still find more researches to prove my opinion. Social expectation especially from teacher and parents makes male students having a better attitude toward mathematics. In contrast, female students who endorsed gender stereotype in mathematics had significantly lower math achievement. Therefore, social expectations carry associated results for math achievements by influencing student's beliefs. That is one of the reasons that boys perform better in mathematics learning.

Boys have some mentality advantages in mathematics learning.

Boys have some mentality advantages in mathematics learning. More specifically, mentality refers to personality and spatial ability. Some researches have confirmed that personality is related to gender differences in mathematics achievement. Some personality such as Conscientiousness, Agreeableness and Openness can be observed in boys and allow boys to perform better in mathematics (Alcock et al., 2014). In addition, a research reports that male students surpass female students at spatial reasoning (Hoffman et al., 2011). The research also reveals that spatial ability differences is partly responsible for girls underperformed in mathematics.

Firstly, to clarify personality, Korpershoek, Kuyper, & van der Werf (2012) use Five Factor Personality Inventory (FFPI) to classify students' personalities. The five global dimensions of personality which conclude the most general factors that can describe the personality structure: Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness. Pečjak et al., (2016) indicate that, on average, boys score higher on the factor of Emotional Stability which related to Conscientiousness and lower on the factors of Agreeableness and Extraversion than girls. Then, Peklaj, Podlesek, & Pečjak (2014) point out that Conscientiousness is one of the most significant direct and indirect influencing factor of math grade. For example, the results of Jolijn Hendriks, Kuyper, Johan Offringa, & Van der Werf, (2008) study indicate that most of students who get higher scores on Conscientiousness also achieve higher scores on math tests. That is, students' attitudes and scores toward mathematics have obviously positive correlations with some kind of personality like Conscientiousness. Further, a study of Hong & Lin, (2011) is in agreement with Jolijn et al (2008). Findings show that male students, not female students, with tendencies of conscientiousness are more likely to have more confidence toward mathematics learning, more interested in learning math, and more involved in academic math activity. Thus, they have mental advantages and perform better in learning math.

In contrast, a study of Jolijn Hendriks et al., (2008) point out that female students tend to be more agreeable, and less emotionally stable than male students. Then, Pečjak, Pirc, & Peklaj, (2016) found more female students have higher scores in Agreeableness, but they reveal that Agreeableness more likely to have negative influence on mathematics achievements. This finding suggests that female students who are more friendly, generous and cooperative generally have lower grades in math than others. So, personalities can be one of the supporting evidences for male students to achieve higher attainments toward mathematics.

Secondly, spatial ability is one of the basic capabilities mong mathematics learning (Hyde, 2016). Among spatial ability, the most significant gender difference is found on mental rotation tasks, which requires the ability to hold images in one's mind while mentally manipulating them, defined by Hyde (2016). On the tests of spatial ability, Ganley & Vasilyeva, (2011) find that males tend to outperform females in both accuracy and speed. Therefore, I can argue that boys have a better spatial ability which allows them to outperform females in mathematics learning.

Further, results from Ganley & Vasilyeva, (2011) are in line with those previous studies. It suggests that gender differences in spatial ability are associated with the differential participation of spatial reasoning in math problem solving may lead to later gender differences in math achievement. For instance, an American study, female students are underperformed in spatial ability tests than males, and the salience of negative difference, Hoffman et al., (2011) point out that it may result in inferior achievements of female students. So, spatial ability, which is an essential ability in learning mathematics, can be another supporting evidence that influences mathematics learning in mental domain.

However, some researches disagree with these supporting evidences. For example, Hong & Lin (2011) believe that differences in mathematics learning should be a better understanding of personality differences instead of gender differences. More specifically, some personalities have influence on mathematics learning but not all boys tend to be Conscientiousness as well as not all girls tend to be Agreeableness. Among spatial ability, there is also another research that suggests female students perform as well as male students in spatial tests (Hyde, 2016).

Nevertheless, some evidences can convince that boys and girls have differences in spatial ability. Then, to refute the disagreement of personality have an influence on mathematics learning, Else-Quest, Hyde, & Linn, (2010) insist students' math performance influenced by it. More specifically, some

personality can give students confidence and others may make students more easily feeling anxious (Campbell & Alberts, 2009). In mental notion, according to Foley et al., (2017) male students' more confidence and have a better mental attitude toward mathematics that can carry positive consequences. In contrast, anxiety will make female students feel no motivation towards math that can carry negative consequences for their math achievement (Rubinsten, Eidlin, Wohl, & Akibli, 2015).

Firstly, among the influence of confidence, data from international survey TIMSS indicate that the percentage of male students in Chinese secondary schools with high self-confidence in learning mathematics is higher than the percentage of female classmates, 61% and 54% respectively. Similarly, the percentage of male students in American and Australia with high self-confidence in learning mathematics is also higher than the percentage of their female classmate (30% vs. 16% and 39% vs. 32%, respectively). These results reveal that male students in secondary schools have more confidence than female students towards mathematics learning, and that encourage them to earn higher scores in mathematics examinations (Hong & Lin, 2011).

Secondly, Math anxiety is defined as a negative affective response to mathematics. Hyde, (2016) find that anxiety of mathematics is one of the most important reasons of underperformed in mathematics learning. Also, Rubinsten, Bialik, & Solar, (2012) believe that math anxiety might be an influencing factor for the inferior achievement of female students in the math education. For example, in the study of Stoet, Bailey, Moore, & Geary (2016), the girl students tend to show an obviously higher rank of mathematics anxiety than boys in most of the countries (82% in 2012). According to Foley et al., (2017), this gender gap in mathematics anxiety have strong relationship with mathematics achievement. Thus, Rubinsten et al., (2012) refer anxiety as a strong predictor of the inferior performance of female students in the mathematics education.

In sum, in the notion of mental domain, male and female students show the difference in spatial skills. Boys perform quicker and more accurate in spatial tests than girls. In addition, despite some scholars arguing personality do not have consistency with gender, but the majority of researches show that in mental domain, some personalities such as Conscientiousness can be significantly observed in male students. This personality has been proven that have positive correlation for mathematics learning. So, personality can encourage male students perform better than female students in mathematics. Meanwhile, in mental domain, confidence and anxiety can be one reason that influences gender differences in math learning. That is why, in term of mental

aspect, boys are more confident in perceiving mathematics learning outcomes whereas girls become anxious instead, that may hinder them to learn math.

Boys have some physical advantages in mathematics learning.

To support the argument that male performs better in mathematics learning, in this part, this study will focus on the organization of brain systems involved in mathematical cognition in females and males. Research shows that gender differences were all localized to the right posterior regions of the brain, where number and space interact (Keller & Menon, 2009). More specifically, this research shows that within the dorsal stream, male students are more activate than females in the right intraparietal sulcus (IPS) and the right angular gyrus regions; within the ventral visual stream, males show significantly higher activation than females in the right lingual.

Further, Keller & Menon (2009) have done a ROI analysis of the dorsal visual stream cluster, they conclude that there is a positive task-related activation in males, not in females conversely. When these two scholars examined the spatial extent of activation, they find that male students as well as more activate than female students, whereas female students have higher deactivation than male students. Similarly, in a parallel analysis of the spatial extent of activation, with females deactivating significantly more voxels than males. Therefore, I can conclude that both boys and girls have positive activation in the IPS, but boys are more active than girls, this is one of the physical advantages which can be convincing evidence that boys have better math learning abilities.

To further quantify brain responses in males and females, Keller & Menon (2009) further analysed brain responses in the dorsal and ventral stream clusters and they find that female student have stronger deactivation both in the dorsal and ventral streams. Meanwhile, within the regions of the dorsal stream, male students are obviously having higher positive activation while the activation of females did not exceed the baseline.

However, few types of research focus on physical domain towards mathematics learning which means that this supporting evidence is not convincing enough. Moreover, another study which focuses on genome-wide, (also belongs to the physical domain) shows that one kind of significant single nucleotide polymorphisms (SNPs) (rs9320913) is associated with mathematics scores ($p = 0.015$), (Zhu, Chen, Moyzis, Dong, & Lin, 2015). But in this study, the authors do not report any result related to gender differences. So, these authors claim that physical element has no relationship for gender differences in mathematics learning. But I believe this argument cannot stand against the finding of Keller & Menon (2009).

To conclude, the physical-related field is a new research domain which can define the influence factors of gender difference in mathematics learning more scientific. This essay finds some article to support the argument that boys have some physical advantages in learning mathematics therefore they perform better than girls. But the supporting evidence is not enough. Thus, I highly recommend future researchers to focus on this field.

CONCLUSION

Taking into account of all these factors, we may conclude that male students outperform female students in mathematics learning. With the above content, social gender stereotypes about students' math ability may lead students to endorse math-gender stereotypes themselves. This kind of stereotypes makes male students more confident whereas female students become more anxious. As a result, boys can perceive higher scores than girls. So, social expectation is one of the reasons behind gender differences in mathematics education in school. Personality and spatial ability, as representors in mentality, it has commonly been proven that another reason for the advantage of male students in mathematics education. Physical advantages for male students in mathematics also can be observed in some literature and research. Though evidence in the physical field is not enough, current evidences suggest that males are more active in some brain areas which are related to mathematics ability. This essay highly recommends future research focus on physical reasons of gender difference in mathematics learning. After critically discussing these three aspects, this essay concludes that male students perform better than female students in mathematics learning in secondary schools.

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