Gender gap in mathematics achievement: Vietnamese students in American Mathematics Competitions

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Addressing gender equality in education has always been one of the crucial Sustainable Development Goals advocated by the United Nations. To achieve this goal, many countries are tackling gender inequality in mathematics and STEM subjects where the achievement gaps historically favoured male students. Vietnam has one of the highest maths performance gaps worldwide, demonstrated by international maths competitions (e.g., PISA) with males often outperforming females. Research on gender gap in maths in Vietnam is, however, still in its infancy, which challenges policy makers and relevant authorities to create positive changes to the current education system. This study analysed test scores of 23,932 Vietnamese students participating in the American Mathematics Competitions 8 (AMC8) from 2016 to 2020 to investigate the issue of gender (in)equality in secondary maths education in Vietnam. Evidence of gender gap was found, especially among the top 500 highest achievers. The research demonstrated that boys showed a higher rate of participation and achieved higher average scores compared to their female peers. Among top achievers, gender gap was in favour of boys, especially in the strand of algebraic content. This study is amongst the first to conduct statistical analyses of maths scores data by gender in Vietnam. It aims to provide guidelines for future research and contribute to policymaking in an attempt to address gender equality in Vietnam's education.

Introduction

A number of studies have illustrated that being competent in mathematics plays an important role in one's personal life and brings opportunities for a brighter career (Ceci & Williams, 2010; Joensen & Nielsen, 2013). Mathematical skill is crucial to managers, scientists and engineers for technical purposes, it also helps individuals develop a wide range of essential skills, including logic building, critical thinking, creativity, problem-solving and effective communication (Basri, 2019; Căprioară, 2015; Kim et al., 2016; Suratno et al., 2019). As a result, the 4th statement of the United Nations Sustainable Development Goals (UN, 2015) upon an equal education clearly advised educators and policy makers to promote the participation and improvement of maths knowledge to all students regardless of their backgrounds (UN, 2015). However, this goal, which aims to ensure equality in educational access and maths education, is challenged. Research on gender gap in USA, OECD countries and Europe indicated that boys were performing better than girls in maths, especially at the top of the performance distribution (Bahar, 2021; Lubienski & Ganley, 2017).

On the other hand, studies on gender gap in developing countries, including SACMEQ countries (e.g., Botswana, Mauritius, South Africa) and Vietnam showed that girls outperformed boys in reading, and the difference in maths performances was minor

(Eurydice, 2010; OECD, 2020). These contrasting research findings suggest that further studies are needed to clarify the existence of a gender gap in maths in specific regions with different demographic characteristics, such as student's age, parental education, socio-economic backgrounds. According to the PISA (Programme for International Students Assessment) data, Vietnam is one of the countries with high gender gaps, yet this phenomenon is receiving little attention from relevant authorities. This reflects a lack of policies to address gender equality in maths education. This study provides empirical evidence on a gender gap in mathematics among Vietnamese students, aiming to emphasise the importance of addressing gender (in)equality in Vietnam maths education, as well as contributing to the worldwide picture of gender equality in maths and STEM subjects.

The test chosen for this study is *American Mathematics Competition 8* (AMC8), often known as one of the most prestigious global maths competitions (Bahar, 2021; Kenderov, 2006). Organised by the Mathematics Association of America (MAA), AMC8 has a deep-rooted history in which its results are often used to select outstanding students for the *International Maths Olympics* (IMO) (Kenderov, 2006). The annual competition is divided into three components: AMC8 (grade 8 and under), AMC10 (grade 10 and under) and AMC12 (grade 12 and under). It is believed to significantly advance students' mathematical ability by helping them develop problem-solving skills (MAA, 2020), as well as increasing their awareness of the educational opportunities (Campbell & Walberg, 2010). Similarly, Andreescu et al. (2008) agreed that AMC is an effective tool to examine various levels of cognition, thereby allowing the differentiation of students' maths competence. Bahar (2021) further added that high achievers from AMCs proved their distinguished maths competence, which later on benefitted both their academic and non-academic skills. As a result, AMC is widely employed by a number of prestigious universities to assess students' mathematical and analytical abilities. Due to its reputation, AMC welcomes 350,000 participants from 6,000 schools in 34 countries worldwide annually (Bahar, 2021).

Vietnamese students have been among the biggest student groups taking part in these competitions, with nearly 24,000 participants in four years, hence chosen for this research. However, it is noted that there is no research analysing AMC performances by Vietnamese students, not to mention the gender gap in their achievements. Therefore this research, which aims to analyse the AMC8 results of more than 23,932 students from 2016 to 2020 by gender, is crucial for educators and policy makers to form an initial understanding of gender gap in the context of maths education in Vietnam. It can also be an inspiration and a useful guideline for future research to further explore the roles of gender in mathematics education.

Literature review

Many authors claim that research on gender gap in maths is crucial to every nation, since in the long run, its presence might contribute to the slowdown of both social and economic development (Cech & Blair-Loy, 2019). Specifically, male mathematical superiority might affect women's access to maths and STEM-related fields, limiting their

high-powered career opportunities in finance, business, science, technology, engineering and mathematics (Joensen & Nielsen, 2013). This might also result in a remarkable lack of female representatives in mathematical, engineering and many other technical departments requiring maths as prerequisites (Hyde & Mertz, 2009).

As aforementioned, there has been a sufficient amount of research examining gender gap in maths tests in numerous countries on students of all age. Studies have demonstrated empirically that male students often showed higher rates of attendance as well as higher test scores in maths competitions, particularly among top achievers (Kenney et al, 2006; Innabi & Dodeen, 2018). However, some research has highlighted that gender difference in maths performances are insignificant at elementary and secondary levels (Lindberg et al., 2010; Robinson & Lubienski, 2011). But other studies have argued that females outperformed in particular strands of maths (Balart & Oosterveen, 2019). The varying research findings suggest that the existence and the size of gender gap might vary across students' age, biological features, socio-environmental and socio-cultural factors, and levels of parental education between and within countries (Fryer & Levitt, 2010). It is further claimed that gender differences decreased over time in both developed and developing countries (Sarouphim & Chartouny, 2017).

Research on gender gap in mathematics

Many studies found evidence of gender gap in maths in numerous countries with varying results depending on students' age. Regarding primary levels, research conducted by the *Trends in International Mathematics and Science Study* (TIMSS) in 2015 demonstrated that 36% of the countries had grade four male pupils overperforming their female peers in maths, 14% saw an opposite result and 50% of the countries did not see any differences in maths performances of two genders (Mullis et al., 2016). The discovery that female students are likely to lose ground relative to males is further strengthened by Robinson and Lubienski's (2011) research, which claimed that in the last 50 years, male primary schoolers predominantly achieved better maths results than female ones in *Scholastic Aptitude Test* (SAT) in the US. Regarding secondary levels, the Organisation for Economic Co-operation and Development (OECD, 2016) conducted an analysis on the PISA results of 15-year-old students worldwide, finding that 41% of the examined countries had male students outperforming female peers, 13% saw an opposite result in which female students performed better than male peers, and 46% saw no differences in two genders' performances. The OECD report also indicated that on average, male students performed better than female peers by 8 points, while this figure was 16 points at the top of the performance distribution. Contini et al.'s (2017) comprehensive research from Italian maths data further confirmed that gender gap was in favour of male students after controlling for family and individual backgrounds. These studies suggested that in many countries, male students performed equal to or better than their female peers in maths at both primary and secondary levels.

In contrast, several studies indicated that female students clearly performed better in maths than their male peers at primary and secondary school settings (Kenney et al., 2006). For instance, Innabi and Dodeen (2018) indicated that 8th grade female pupils in

Jordan obtained higher results in science research and international mathematics competitions. Specifically, male students performed better in the more difficult and unfamiliar maths questions, while female peers outperformed in familiar ones which were more relevant to real-life scenarios. Balart and Oosterveen's (2019) research on maths performances of 15-years-old students in the US between 2009 and 2016 further demonstrated that female students were mathematically superior in some areas, including two-digits division, pie-chart reading and maths problem solving. Indeed, the contradictory research findings suggested that there have been more factors being responsible for the existence of gender gap in maths besides students' age.

First, from a social perspective, studies indicated that socio-environmental and socio-cultural elements might have caused and deepened the disparities in maths performances between male and female students of all ages (Ghasemi & Burley, 2019). Specifically, Cvencek, Meltzoff and Greenwald (2011) indicated that the social norms and prejudices regarding gender, which suggested that males tended to be more interested and thus outperform females in logic and scientific matters, gradually forming a perceived gender-specific stereotype that males are inevitably better than females in mathematical-related fields. This social belief not only affects the perceptions of teachers who tend to set higher expectations for male students, but also impacts the perceptions of students towards their own abilities, their behaviours and motivation to maths learning (Jaremus et al., 2020). In fact, Markovits and Forgasz (2017) and Metcalf (2018) both pointed out that female students tend to show less self-efficacy and self-concept (or self-confidence) in solving maths-related questions. Heckman and Kautz (2012) highlighted that self-esteem and self-confidence are crucial predictors of success in the labour market and in life, suggesting that females are placed in disadvantaged positions due to their insecurity of mathematical abilities.

Second, from a biological perspective, researchers argued that the gender differences in the brain structure and hormone might have affected their learning and perceptions of number and space. Specifically, Spelke (2005) proposed genetic arguments explaining why boys are naturally more superior in maths compared to girls, that include their (i) inherent deeper interest in objects *versus* people; (ii) profiles in numerical and spatial abilities that are conductive to better aptitude in solving mathematics and (iii) higher dispersion in spatial and quantitative abilities. These biological differences might have benefitted the development of the males' brains in solving maths problems. However, empirical evidence has not been provided to clarify these arguments, which prevents any conclusion regarding the importance of biological factors on learners' cognitive abilities.

Apart from its presence, the size of gender gap in maths was also discussed widely among researchers. Hyde et al.'s (1990) systematic review, which examined more than 100 studies before 1990 on nearly 4 million student participants, indicated that the gender disparity in maths achievement decreased from 0.31 to 0.14 within three decades. Another systematic review by Lindberg et al. (2010) on 242 studies after 1990 produced a similar result, in which the gender gap in maths performances saw a noticeable decline. The most recent research by Mejias et al. (2021) on students aged 5 to 18 in Chile further confirmed that the gender gap in maths achievement has been reduced. In fact, in Vietnam, male students

had been historically mathematically superior to their female peers, yet this trend is changing. Specifically, compared to PISA 2012, PISA 2015 saw a decrease in the gaps between male and female students' performances. This is because the male students did not perform as well, while female students' performances remained unchanged.

A number of studies have focused also on gender gaps in a student's schooling circle. Mejias et al. (2021) and Purpura and Reid (2016) highlighted that gender gap in maths began very early from kindergarten and continue to become more obvious towards male superiority in secondary and high school settings, and even higher education. Mejias et al. (2021) claimed that the biggest gap can be seen during secondary levels, though decreasing slightly between year 10 and year 12, especially among top achievers. However, Robinson and Lubienski (2011) indicated that gender gap was at peak in primary levels and decreased over time. These discordant findings suggest that there is no clear conclusion to date on gender gap trends.

Research on gender gap among top achievers

In contrast to the contradictory results of general gender gap research, studies on the top maths achievers consistently argued that the gender gap was more obvious among the top of the distribution. Analysing the performances of 120,000 students from the 2007 AMC8, Ellison and Swanson (2010) found that among the highest 6% of all students who achieved absolute score of 100, the ratio of male and female was 4:1, which means that only 20% among the top achievers was female. The study also found that the gender gap was more conspicuous in challenging questions. In addition, Bahar (2021) who analysed the performances of more than 2,250,000 students from 2009 to 2019 also pointed out that regardless of the increasing rate of participation every year, there were differences in the performances of male and female students every year, especially in the top 1% and 5% highest achievers. Fryer and Levitt (2010) and Contini et al. (2017) added that regardless of different family and individual backgrounds (e.g., family structure, ethnic group, socio-economic status), girls lost ground to boys at the top of the distribution of scores. These studies suggest that among high achievers, male students were more mathematically superior compared to their female peers.

To conclude, the varying research findings about the gender gap in maths in various countries suggest that there are many layers underneath this circumstance. Its existence, size and tendency are dependent on various factors, including students' age, biological features, socio-environmental and socio-cultural factors, levels of parental education and country of origin. The gap appears more conspicuous among the top achievers and less observable at the bottom of the distribution of scores, suggesting that there are still unknown factors underlying gender gap in maths. Bahar (2021) suggested that the mathematical factor, or types of maths, might also have an impact on students' performances. Specifically, the study demonstrated that boys performed better than girls in algebra with the biggest score difference of 2.19 points. As for Vietnam, there is currently very limited research on the presence of gender gap in maths performances, including national and international tests, not to mention the factors explaining such issue.

According to Duflo (2012), tackling gender inequalities in maths might not be necessary for economic development as often argued, however, gender equality might be worth addressing. This is because if gender gap in favour of boys exists, there is a possibility that it limits girls' accessibility and opportunities to pursue higher education in technological and science-related fields that often require advanced levels of maths. Anaya, Stafford and Zamarro (2017) highlighted that this might be a reason for gender-specific lower salaries, restrictions in women's promotion at work, and their underrated position in the society (Cech & Blair-Loy, 2019). A long-term consequence of gender gap ignorance can be that the role of women in science is being under-utilised, resulting in low representation of women in STEM fields (Ellison & Swanson, 2010). Vice versa, this lack of female representation in these fields leads back to the lower rate of female participants in international maths competitions (e.g., IMO), and the lower number of female professors in maths-related fields at universities (Hyde et al., 2008).

Recognising the importance of addressing gender gap in mathematics, this paper starts with investigating the existence of gender gap in mathematics among 23,932 grade 6 to 8 Vietnamese students via the AMC8 test results from 2016 to 2020, then focuses on the gap among the top of the distribution. First, it provides detailed statistical descriptions of students' AMC8 participation rates and scores by gender in Vietnam. Second, it analyses the performances of the top 500 achievers to explore whether the size of the gap differs across the performance distribution. Third, it compares their test scores in specific strands of maths, including algebra, logics, geometry, statistics and probability to initiate the roles of mathematical factor in the issue of gender gap. Due to a lack of data resources, this research does not address other mentioned factors explaining the gender gap (e.g., socio-environmental, levels of parental education). The outcome of this research is expected to (i) validate the general findings on gender (in)equality in maths; (ii) cast light on the importance of gender study in maths education in Vietnam for future research; and (iii) raise awareness of educators and policy makers in addressing gender equality in maths curriculum.

Method

The data used for this study, provided by the Vietnam Ministry of Education and Training, covers all available AMC8 data from the year when Vietnamese students first participated in AMC8 (2016) to the time of the study (2021). The annual exams are designed by the Mathematical Association of America (MAA), assigned to AMC8 representatives in Vietnam in strict confidence and distributed by the Ministry of Education and Training to students. Any students in Vietnam from grades 8 and under can register via their schools or as individuals. The finished exams are sealed and sent to relevant authorities for automatic grading. The scores are then saved in a digital space and transferred back to the MAA for within country and cross-country comparison before being distributed to students from all over the world. The participation fee of AMC8 is approximately US$12 per student (including the registration fees and the order of the paper) (AMC8, 2022). The average amount that Vietnamese students spent on AMC8 is

therefore approximately US$60,000/year. The participation fees are paid by the families of the students who wished to take part in the competitions voluntarily.

This study uses *SPSS version 26* software to compare and analyse the rates of participation and the performances of 23,932 Vietnamese male and female students in the AMC8 from 2016 to 2020. The study then focuses on analysing the test scores of the top 500 Vietnamese achievers, as well as highlighting gender disparities in specific strands of maths, that include algebra, geometry, statistics and probability and logics.

Results and discussion

The gender gap in participation rates

The number of students participating in AMC8 has increased significantly, from 2630 students in 2016 to 6013 in 2020 (Table 1). This trend reflects an improvement in social awareness in terms of talent recognition and the importance of international competitive environments in facilitating talented students in the fields of science and technology (Kenderov, 2006; Geretschlager, 2020).

Table 1: Comparing rates of participation from 2016 to 2020
(use web or PDF reader 'zoom in' function to read)

Gender	2016			2017			2018			2019			2020		
	No. P	No. Vn	%	No. P	No. Vn	%	No. P	No. Vn	%	No. P	No. Vn	%	No. P	No. Vn	%
Male	1741			3293			3728			3091			4045		
Female	889			1743			1999			1403			1968		
Total	2630	5.327m	.04	5036	5.236m	.09	5727	5.456m	.10	4494	5.661m	.07	6013	5.931m	.10

No. P = number of participants; No. Vn = Number of millions of students in same grade cohorts in Vietnam

Table 1 further demonstrates that overall, the figure for male participants doubled that for females in every year from 2016 to 2020. The number of male participants was always higher than females when comparing each grade from grade 6 to 8. The number of Vietnamese students participating in AMC8 accounted for 0.04% to 0.10% of the total student population in grades 6 to 8, with the highest figures found in 2018 and 2020. It is worth noting that students participated in the AMC8 on a completely voluntary basis, which suggests that this figure indicates the levels of interest in international mathematics competitions amongst Vietnamese students.

Table 2 shows that the higher grades saw more obvious differences in the rates of participation, in which the ratio of male and female students averaged 1.82 for grade 6, 2.18 for grade 7 and 2.2 for grade 8 during 2016-20. The highest ratio was found among year 8 students in 2019 at 2.6. A possible explanation for this circumstance can be that girls of this age and their families preferred spending on other matters, or tended to prefer less mathematically driven professions. This result was consistent with existing findings, which previously argued that boys were more interested in maths competitions than girls, driven by either biological or social factors (Morin, 2015; Root-Bernstein et al., 2019).

Table 2: Comparing rates of participation by grades from 2016 to 2020 (use web or PDF reader 'zoom in' function to read)

Grade	Gender	2016		2017		2018		2019		2020	
		No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
6	Male	586	61.0	1385	64.4	1616	64.3	1247	66.6	1479	65
	Female	375	39.0	767	35.6	897	35.7	624	33.4	795	35
	Ratio M:F	1.6		1.8		1.8		2.0		1.9	
7	Male	543	71.1	929	64.6	1172	66.6	946	68.8	1325	67.3
	Female	221	28.9	508	35.4	515	33.4	430	31.3	645	32.7
	Ratio M:F	2.5		1.8		2.3		2.2		2.1	
8	Male	612	67.6	977	67.6	940	64.6	897	72.0	1240	70.2
	Female	293	32.4	468	32.4	515	35.4	349	28.0	527	29.8
	Ratio M:F	2.1		2.1		1.8		2.6		2.4	

The gender gap among Vietnamese students in AMC8 from 2016 to 2020

The data from Table 3 demonstrates significant differences in the performances of Vietnamese male and female participants from 2016 to 2020 ($p = .000 < .01$). The average results of male participants were 0.66 to 2.07 points higher than females from (Table 3). Male students outperformed their female peers in AMC8 across all examined years. This results further validates some of the previous research finding that male pupils tended to perform better in maths competitions than female at secondary levels (Hyde et al., 1990; Robinson & Lubienski, 2011). This result, however, has contradicted other studies, for instance, Ho et al. (2020), which argued that there were no differences in maths performances of male and female pupils.

Table 3: Comparing average results of all participants by grades from 2016 to 2020 (use web or PDF reader 'zoom in' function to read)

Year		Grade 6				Grade 7				Grade 8			
		Gender		Sig. (2-tailed)	Diffs (1) - (2)	Gender		Sig. (2-tailed)	Diffs (1) - (2)	Gender		Sig. (2-tailed)	Diffs (1) - (2)
		M (1)	F (2)			M (1)	F (2)			M (1)	F (2)		
2016	Number	586	375	*0.000*	0.96	543	221	*0.000*	1.17	612	293	*0.000*	1.43
	Average	10.01	9.05			11.82	10.65			13.37	11.94		
2017	Number	1385	767	*0.000*	0.69	929	508	*0.001*	0.66	977	468	*0.000*	1.29
	Average	8.79	8.1			10.96	10.3			12.31	11.02		
2018	Number	1616	897	*0.000*	0.87	1172	587	*0.000*	1.54	940	515	*0.000*	1.05
	Average	7.88	7.01			9.6	8.06			10.54	9.49		
2019	Number	1247	624	*0.000*	1.45	946	430	*0.000*	1.75	879	349	*0.000*	2.07
	Average	8.3	6.85			10.92	9.17			12.6	10.53		
2020	Number	1479	796	*0.000*	1.39	1325	645	*0.000*	1.60	1240	527	*0.000*	1.60
	Average	9.52	8.13			11.15	9.55			12.26	10.66		

Table 3 further demonstrates that the differences in performances between male and female participants increased every year. This result validated previous research (Purpura & Reid, 2016; Mejias et al., 2021), which agreed that the gender gap in maths performance tended to increase from primary to secondary, peak at secondary levels and stay

unchanged at high school and even higher education settings. However, these findings do not agree with Robinson & Lubienski (2011), who found that the gender gap started to decrease at secondary levels. Our finding that the gender gap is likely to increase over time might reflect a current trend in the labour market in Vietnam, where the average salary of females has been much lower than males in maths and STEM-related fields, and the number of female workers in science and technology was also lower (Luong, 2015).

Gender gap at the top of the performance distribution

Table 4 demonstrates differences in the performances of the top 500 Vietnamese achievers (p = 0.05) in all examined years, all grades. In most years, male pupils outperformed their female peers except for year 2016 and 2019 for 7th graders. The biggest score difference in favour of boys can be found among sixth graders in 2019 at 1.07 points. Year 2019 saw the most notable statistically significant differences between the performances of Vietnamese male and female students, in which male students outperformed their female peers.

Table 4: Comparing average results of the top 500 best achievers by grades from 2016 to 2020 (use web or PDF reader 'zoom in' function to read)

Year		Grade 6				Grade 7				Grade 8			
		Gender		Sig. (2-tailed)	Diffs (1) - (2)	Gender		Sig. (2-tailed)	Diffs (1) - (2)	Gender		Sig. (2-tailed)	Diffs (1) - (2)
		M (1)	F (2)			M (1)	F (2)			M (1)	F (2)		
2016	Number	322	178	*0.003*	*0.78*	375	125	0.089	0.55	361	139	*0.001*	*0.87*
	Average	12.85	12.07			13.89	13.34			16.47	15.6		
2017	Number	357	139	0.787	0.06	349	151	0.559	-0.06	393	107	*0.025*	*0.50*
	Average	13.32	13.26			14.81	14.87			16.26	15.76		
2018	Number	382	118	0.064	0.33	394	106	*0.000*	*0.86*	350	150	0.127	0.32
	Average	12.08	11.75			13.55	12.69			14.32	14		
2019	Number	394	106	*0.000*	*1.07*	395	105	*0.006*	*0.79*	412	88	*0.008*	*0.80*
	Average	12.36	11.29			14.8	14.01			16.39	15.59		
2020	Number	389	111	*0.033*	*0.40*	404	96	0.076	0.41	407	93	*0.002*	*0.62*
	Average	13.99	13.59			15.56	15.15			16.66	16.04		

The data in Tables 5, 6 and 7 suggest that in general, a gender gap exists in AMC8 performances among the top 500 best Vietnamese achievers in all grades, which further exemplified previous studies, including Ellison and Swanson (2010) and Bahar (2021). However, the differences among the top students were not as obvious as general AMC8 performances of all Vietnamese participants. Specifically, Table 5 indicates that among the top grade six achievers, for whom the most frequent scores ranged between 10 and 25 points, most of these highest scores were attained by male students. In every year from 2017 to 2020, every student who achieved 21 points and above was male, while female students were likely to achieve mostly in a lower range, 10 to 15 points.

Table 5: Male-female ratio of the top 500 grade six achievers from 2016 to 2020 (use web or PDF reader 'zoom in' function to read)

2016			2017			2018			2019			2020		
Total points	Gender		Total points	Gender		Total points	Gender		Total points	Gender		Total points	Gender	
	M%	F%		M%	F%		M%	F%		M%	F%		M%	F%
10	58.9%	41.1%	11	68.0	32.0	10	75.8	24.2	9	82.4	17.6	12	75.2	24.8
11	63.3	36.7	12	71.4	28.6	11	74.4	25.6	10	73.8	26.2	13	78.0	22.0
12	61.4	38.6	13	74.7	25.3	12	75.8	24.2	11	67.0	33.0	14	74.7	25.3
13	71.7	28.3	14	82.7	17.3	13	67.3	32.7	12	80.9	19.1	15	71.4	28.6
14	59.1	40.9	15	72.9	27.1	14	84.0	16.0	13	89.4	10.6	16	89.7	10.3
15	74.2	25.8	16	76.7	23.3	15	85.0	15.0	14	85.7	14.3	17	90.0	10.0
16	62.5	37.5	17	50.0	50.0	16	75.0	25.0	15	88.9	11.1	18	86.7	13.3
17	70.0	30.0	18	81.8	18.2	17	100	0.0	16	82.4	17.6	19	88.9	11.1
18	88.2	11.8	19	60.0	40.0	18	83.3	16.7	17	92.9	7.1	20	100	0.0
19	71.4	28.6	20	75.0	25.0	19	100	0.0	18	100	0.0	21	50.0	50.0
20	77.8	22.2	21	100	0.0	21	100	0.0	19	100	0.0	22	100	0.0
21	83.3	16.7							20	100	0.0	25	100	0.0
22	100	0.0							21	100	0.0			
23	100	0.0							22	100	0.0			
24	65.4	34.6							23	100	0.0			

Compared to 6th graders, the gender gap among 7th grade achievers was less obvious with more fluctuation in their performances. Specifically, in 2016, the highest achievement, 24 points, was attained only by females, while the second highest achievement, 23 points, was attained only by male participants. In contrast, in 2019, the highest achievement, 24 points, was attained equally by both male and female students. The gender gap was shown clearly in 2017 and 2018, when male participants clearly outperformed their female peers and were likely to achieve higher points.

Table 6: Male-female ratio of the top 500 grade seven achievers from 2016 to 2020 (use web or PDF reader 'zoom in' function to read)

2016			2017			2018			2019			2020		
Total points	Gender		Total points	Gender		Total points	Gender		Total points	Gender		Total points	Gender	
	M%	F%		M%	F%		M%	F%		M%	F%		M%	F%
10	72.9	27.1	12	65.7	34.3	11	65.5	34.5	11	46.7	53.3	13	77.6	22.4
11	60.9	39.1	13	72.9	27.1	12	78.1	21.9	12	76.9	23.1	14	78.0	22.0
12	79.0	21.0	14	69.4	30.6	13	75.0	25.0	13	73.5	26.5	15	79.6	20.4
13	80.7	19.3	15	65.9	34.1	14	84.9	15.1	14	80.0	20.0	16	85.5	14.5
14	76.9	23.1	16	78.4	21.6	15	83.0	17.0	15	83.6	16.4	17	73.6	26.4
15	77.5	22.5	17	73.9	26.1	16	96.0	4.0	16	74.6	25.4	18	93.9	6.1
16	80.5	19.5	18	58.1	41.9	17	93.3	6.7	17	93.8	6.3	19	85.0	15.0
17	79.3	20.7	19	64.7	35.3	18	83.3	16.7	18	90.0	10.0	20	80.0	20.0
18	81.5	18.5	20	68.8	31.2	19	100	0.0	19	93.3	6.7	21	87.5	12.5
19	75.0	25.0	21	80.0	20.0	20	100	0.0	20	86.7	13.3	22	100	0.0
20	72.7	27.3	22	100	0.0	21	100	0.0	21	83.3	16.7	23	100	0.0
21	80.0	20.0	23	100	0.0	22	0.0	100	22	100	0.0	24	100	0.0
22	75.0	25.0				23	100	0.0	23	85.7	14.3			
23	100	0.0							24	50.0	50.0			
24	0.0	100												

According to Table 7, among 8th graders, the highest grades in most years, 24 and 25 points, belonged to male students, except year 2019 in which a third of the high achievers was female. Similar to the 6th graders, in general, the male 8th graders clearly performed better than their female peers, with from 60-100% of boys dominating these high scores in all years.

Table 7: Male-female ratio of the top 500 grade eight achievers from 2016 to 2020 (use web or PDF reader 'zoom in' function to read)

2016			2017			2018			2019			2020		
Total points	Gender		Total points	Gender		Total points	Gender		Total points	Gender		Total points	Gender	
	M%	F%		M%	F%		M%	F%		M%	F%		M%	F%
12	76.2	23.8	13	71.4	28.6	11	76.9	23.1	13	74.6	25.	14	77.6	22.4
13	67.1	32.9	14	79.5	20.5	12	69.9	30.1	14	80.6	19.4	15	75.4	24.6
14	66.7	33.3	15	77.9	22.1	13	64.8	35.2	15	79.4	20.6	16	83.9	16.1
15	62.7	37.3	16	72.0	28.0	14	67.1	32.9	16	76.1	23.9	17	77.0	23.0
16	68.3	31.7	17	84.1	15.9	15	80.7	19.3	17	92.9	7.1	18	84.0	16.0
17	75.0	25.0	18	75.6	24.4	16	60.0	40.0	18	82.2	17.8	19	91.7	8.3
18	82.1	17.9	19	71.4	28.6	17	73.1	26.9	19	90.2	9.8	20	89.3	10.7
19	71.0	29.0	20	85.0	15.0	18	84.2	15.8	20	84.2	15.8	21	100	0.0
20	88.0	12.0	21	92.3	7.7	19	72.2	27.8	21	94.7	5.3	22	85.7	14.3
21	77.3	22.7	22	100	0.0	20	100	0.0	22	90.0	10.0	23	100	0.0
22	93.3	6.7	23	100	0.0	21	75.0	25.0	23	100	0.0	24	100	0.0
23	75.0	25.0	24	100	0.0	22	100	0.0	24	100	0.0			
24	100	0.0	25	100	0.0	24	100%	0.0	25	66.7	33.3			
25	100	0.0												

In summary, the gender gap is found clearly among AMC8 performances of 6th and 8th graders with male students outperforming females. Among 7th graders, female students showed slightly better performances in some years. However, in general, the gender gap was in favour of boys in most AMC8 competitions from 2016 to 2020, in which the percentage of female pupils who achieved the highest possible grade was low. This finding aligns with Ellison and Swanson's (2010) study on AMC 2007 which demonstrated that the ratio of male and female achieving 100 points (6% highest achievement) was 4:1. This conclusion helps validate the general finding that male students are better in maths competitions. In fact, in Vietnam, most students who had taken part in the International Maths Olympiads (IMOs) from 1974 to 2021 were male (IMO, 2021). Occasionally there were some female attendances, but the figure was very limited (IMO, 2021). Moreover, 100% of gold medallists and highest achievers in IMOs were male participants (IMO, 2021). As mentioned previously, there are a number of factors that might explain for gender gap in maths. However, due to the non-experimental nature and insufficiency of the given data, causal interpretation and explanations for gender gap in Vietnam cannot be inferred. Therefore it is suggested that future studies further investigate the reasons behind this inequality, whether it comes from socio-environmental, biological, parental or educational factors (e.g., teaching methods, classroom environments, teachers' bias). Whichever explanation it might be, it is crucial for the educators and policymakers to urgently address gender inequality in maths education in Vietnam in an attempt to increase women's representation in maths and STEM-related fields.

Gender gap according to specific strands of maths

The differences in students' performances can be investigated for specific strands of maths: algebra, geometry, statistics and probability and logics (Table 8). In every year from 2016 to 2020, algebra saw gender differences in the performances of all three grades inclining towards boys. Specifically, male students performed noticeably better in algebra than females from 0.36 (6th grade in 2017) to 1.1 points (8th grade in 2019). In logics and geometry, the differences were less obvious, ranging from 0.1 to 0.4 points in favour of boys, except for the year 2020 in which grade 6 females performed better than their male peers by 0.03 points in geometry. Similarly, differences were also found in statistics and probability, in which male pupils mostly performed better than females by 0.1 to 0.4 points except for the sixth graders in 2017. To conclude, in most strands of maths and grade levels, male participants outperformed their females, with some exceptions in sixth grade. The biggest gender differences were found in algebra, while the case was not as obvious in geometry, statistics and probability, and logics. This result aligns with Bahar (2021) who found that males outperformed females in algebra with differences between 1.02 and 2.19 points.

Table 8: Comparing average results of participants by gender according to specific strands of maths (use web or PDF reader 'zoom in' function to read)

Year		Grade 6				Grade 7				Grade 8			
		Gender		Sig. (2-tailed)	Diffs (1) - (2)	Gender		Sig. (2-tailed)	Diffs (1) - (2)	Gender		Sig. (2-tailed)	Diffs (1) - (2)
		M (1)	F (2)			M (1)	F (2)			M (1)	F (2)		
2016	Algebra	6.59	5.93	*0.000*	0.660	7.84	7.09	*0.000*	0.750	8.74	7.98	*0.000*	0.760
	Logics	0.66	0.59	0.125	0.070	0.86	0.67	*0.001*	0.190	0.97	0.83	*0.007*	0.140
	Geo	1.33	1.23	0.980	0.100	1.59	1.29	*0.000*	0.300	1.75	1.52	*0.000*	0.230
	Stats	0.68	0.66	0.696	0.020	0.79	0.70	0.114	0.090	0.90	0.74	*0.005*	0.160
2017	Algebra	5.28	4.92	*0.000*	0.360	6.33	5.96	*0.001*	0.370	7.05	6.33	*0.000*	0.720
	Logics	1.59	1.36	*0.000*	0.230	1.92	1.84	0.231	0.080	2.20	1.87	*0.000*	0.330
	Geo	1.68	1.52	*0.003*	0.160	1.83	1.69	0.610	0.140	2.33	2.12	*0.008*	0.210
	Stats	0.21	0.24	0.213	- 0.030	0.30	0.24	*0.010*	0.060	0.31	0.29	0.666	0.020
2018	Algebra	4.05	3.45	*0.000*	0.600	5.09	4.16	*0.000*	0.930	5.49	4.85	*0.000*	0.640
	Logics	0.86	0.82	0.248	0.040	1.07	0.95	*0.004*	0.120	1.15	1.10	0.223	0.050
	Geo	1.55	1.41	*0.001*	0.140	1.88	1.54	*0.000*	0.340	2.18	2.01	*0.006*	0.170
	Stats	1.14	0.92	*0.000*	0.220	1.42	1.06	*0.000*	0.360	1.58	1.44	*0.029*	0.140
2019	Algebra	3.48	2.81	*0.000*	0.670	5.00	4.00	*0.000*	1.000	5.65	4.54	*0.000*	1.110
	Logics	1.54	1.34	*0.000*	0.200	1.91	1.55	*0.000*	0.360	2.19	1.84	*0.000*	0.350
	Geo	2.30	1.94	*0.000*	0.360	2.65	2.43	*0.001*	0.220	3.20	2.82	*0.000*	0.380
	Stats	1.02	0.84	*0.000*	0.180	1.29	1.18	0.074	0.110	1.63	1.41	*0.002*	0.220
2020	Algebra	4.53	3.78	*0.000*	0.750	5.18	4.46	*0.000*	0.720	5.62	4.89	*0.000*	0.730
	Logics	2.57	2.36	*0.001*	0.210	3.02	2.76	*0.000*	0.260	3.25	2.99	*0.000*	0.260
	Geo	0.64	0.67	0.413	- 0.030	0.73	0.66	0.051	0.070	0.90	0.82	0.059	0.080
	Stats	1.10	0.77	*0.000*	0.330	1.47	1.04	*0.000*	0.430	1.69	1.27	*0.000*	0.420

Conclusion and implications

To conclude, there have been a great number of studies worldwide examining gender gap in students' maths performances. This study sought to further validate these general findings by adding the perspective of Vietnam maths data in AMC8, grade 8 and under from 2016 to 2020. After analysing the rates of participation and students' test scores by gender, results showed that male students attained higher rates of participation, and the gender gap was in favour of male participants. The gap also appeared among the top 500 achievers of all grades. Specifically, among sixth and eighth graders, male students outperformed females, though in case of 7th graders, females performed slightly better than males. Male pupils were found to perform better than their female peers in most strands of maths (e.g., algebra, geometry, logics, statistics and probability), and the most obvious was algebra as found in previous studies.

While the main finding of this study, that male students generally outscore females in maths, aligns with many existing studies conducted in USA, OECD and European countries, this finding contradicts previous research in Vietnam and other developing countries, which had concluded that differences in maths performances between genders was minor. This suggests that further research is strongly recommended in order to clarify the consistency of the gap in certain contexts (international or domestic competitions) and reasons behind these gaps. Due to the lack of data resources, causal explanations for gender gap found in this study cannot be inferred. In other words, the analysis of the reasons why gender gap exists and evolves and what can be done is beyond the scope of this paper.

As this study examines only AMC8, the findings do not represent the performances of Vietnamese students in other domestic and international maths competitions. It is highly recommended that future studies should focus on (i) examining the factors influencing the existence, size and tendency of gender gap in Vietnam; (ii) finding out whether students' performances differ among different tests, including domestic and international maths competitions and possible reasons for such circumstances; and (iii) conducting systematic comparisons between analyses of Vietnamese data and the rest of the world, to obtain a more comprehensive understanding of the issue and provide optimal solutions to promote gender equality in maths education in Vietnam. There is also the need for gender gap research in the context of Vietnam education to go beyond the examination of a single subject into broader disciplines, including STEM, health sciences, education, law and business studies, as well as into occupational fields including social services, retailing, construction, transport and so on. The issues of gender indeed show complex variations; however, it is noted that the gap found does not necessarily mean a failure of gender equity.

For now, since evidence of gender gap is provided, it is important for relevant authorities and policy makers to discuss the need to introduce gender equality policies in the Vietnamese educational system. Lloyds, Walsh and Yailagh (2005) suggested a need to create gradual changes in societal perceptions towards male mathematical superiority. This can be done by starting to draw attention to females' mathematical potentials and

development, as well as encouraging them to explore their employability options in maths and STEM-related fields.

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