The Gender Gaps in Foundation-Level Mathematics Performances at the National University of Samoa: An Exploratory Analysis

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Abstract

Investigating the gender gaps in mathematics scores is used by maths educators and researchers to gain a deeper understanding of students' performances. This exploratory study analyses scores in mathematics courses offered in the National University of Samoa Foundation programs. Using statistical tests to understand the nature and extent of the gender gaps in performances, the results show that while females dominate enrolment numbers, overall performance in terms of marks is dominated by males. The study concludes that more research is needed and critical in unearthing relevant evidence to inform policy and strategies to support maths learning of both male and female students.

Keywords: Mathematics performance, gender, Samoa

Introduction

Examining gender gaps in mathematics scores is a common approach used by maths educators and researchers to gain a deeper understanding of students' performances. Historically, persistent patterns of boys outnumbering and outperforming girls in science, technology, engineering, and maths (STEM) subjects are identified (Lee and Burkham 1996; Hill et al, 2010). Recent assessments show that in some countries, the gap has narrowed substantially and a reverse situation favouring girls exists (Cappelen et al, 2019). These patterns are concerning to education planners, policymakers and researchers interested in gender and social equality. In Samoa, existing studies point to poor performances in maths across primary and high schools and pre-degree levels at the NUS (Afamasaga-Fuata'i, 2002; Government of Samoa, 2020). However, applying a gender lens to examining such performances does not exist. For Foundation maths courses, there is no published analysis on scores and what they portray. Broad trends based on aggregated data are known but these do not fully recognise possible implications for unique challenges experienced by boys and girls in maths. The assumption that aggregated results are gender-neutral and unproblematic needs to be examined.

Three questions underpin the current analysis: *What do the gender gaps in students' marks in maths look like? What do the gender gaps in maths scores suggest? What are the implications of the gender gaps for future research?* Drawing on Foundation maths scores between 2015 and 2019 and my own experience as a maths educator, the analysis applies a gender perspective to reading and interpreting enrolment numbers and scores, and applying statistical tests to confirm initial interpretations. My interest in the gender gaps in students' performance stems from an intellectual curiosity about gender and maths, in particular wanting to know if the literature parallels the situation in Samoa. The analysis indicates that (i) the gender gaps favouring female students in terms of enrolment and total pass numbers exist; (ii) the gender gaps suggest that in terms of the overall performance, male students dominate and, (iii) there is significant potential for in-depth research in this area.

The article has four sections. Section one focuses on the literature review. Section two discusses the methodology including the data, data source, and the analysis process. Section three presents the results and their discussion. This is followed by the concluding section with an emphasis on the results implications for future research.

Literature Review

A growing literature on gender and STEM subjects at school and tertiary-level education has attracted the attention of not only gender scholars but also maths educators. As noted earlier, part of my own curiosity and interests in the subject comes from this literature. As a state of wonder, intellectual curiosity is about seeing opportunities for intellectual engagement, acquiring facts and knowledge, or simply the 'drive to know' (von Stumm et al, 2011). This 'drive to know' about the gender differences in the NUS Foundation maths scores has led to this article. Drawn to stimulating research by maths education researchers (for example: Gill, 1997; Forgasz and Leder, 2017; Myers et al, 2019; Przybyla-Kuchek, 2020), I was keen to explore what the situation looks like with the NUS Foundation students' performances and implications for future research.

A broad context to performances in Foundation maths was noted by Afamasaga-Fuatai in the early 2000s. She argued that there was a direct impact of poor primary and high school results on Foundation and degree levels performances. Her 2002 analysis gives a daunting picture of school maths results in the latter half of the 1990s, arguing that students' performances worsen as they move from primary through to secondary level. Furthermore, "[f]or those entering pre-degree programs at NUS, their weak understanding and ineffective application of fundamental principles to solve problems permeate their study of mathematics and impede their abilities to cope with more advanced mathematics" (Afamasaga-Fuata'i, 2002, 6). She points to a major consequence of this trend that

> the prescribed two semester curriculum to prepare them for university studies is severely comprised as time is taken out for remedial work. Most of the misconceptions at this level are well ingrained and often difficult to overcome in the first semester without some sacrifices for both student and lecturer for extra work outside of scheduled class time.

The acknowledgement of the problem some twenty years ago was accompanied by a clear call for research as part of the NUS's effort to rectify poor performance and high failure rates in maths (*Ibid*., p. 9). Although a specific gender gap analysis was missing, reference was made to the fact that "[g]ender performance in Samoa in terms of grade averages show that boys consistently do better than girls over the years" (*Ibid, p.4*). As commonly known, STEM subjects have historically been male dominated worldwide. Research including that by mathematics education researchers identifies the gender gaps and low numbers of females in STEM education and employment. Australia, for example has a severe imbalance in tertiary enrolments and a similar pattern is identified in many other countries including Samoa (Marginson et al., 2013). In terms of actual scores, boys have historically outperformed girls in maths and science subjects (Hill et al, 2010). The implications of this trend have been that employments in STEM fields have also been dominated by men. From a gender equality perspective, this is an issue of concern and the persistently lower numbers of women in STEM employment is a problem related back to gender related barriers, challenges, and performances in education (Mullet & Kettler, 2017).

A recent Samoan government report however notes that "The numeracy level for females at year 6 is low but stable and decreased for males with only 4 out of 10 male students showing proficiency in numeracy compared to 6 out of 10 for females." (Government of Samoa, 2020, 62). Compared to the situation in the late 1990s where boys were consistently high achievers in maths, the current one is a reverse trend with “girls outscoring boys at all levels of primary and secondary schools” (Ibid. p. 62). Consequently, “the most pressing challenge” for educators is “the poor results for boys in terms of enrolment and secondary and tertiary levels and the quality of education outcomes at all levels of education in particular in secondary level especially for boys.” (p. 63). As experienced in other countries, these trends are often regarded as a symptom of the so-called ‘boy crisis’ (Cappelen et al, 2019). Proponents argue that this symptom has significant implications for potential inequalities and decreasing labour market participation among men. Echoing earlier calls for research, a Samoan Government 2020 report strongly emphasises that “research into the underlying causes of these trends is urgently needed.” (p.63).

Responding to the call for research, this article uses a gender disaggregated approach to students’ scores in Foundation maths and statistics. This is important because while the magnitude of female enrolment and numbers passing maths is said to have improved over the years, there is limited analysis on the levels of scores, and what these might mean. In addition, virtually no evidence exists on the completion rates of girls taking Foundation maths or science programs especially in terms of degree completion, or jobs they eventually take or end up in. It is these dynamics and broader implications of the gender gaps on girls’ employment in STEM fields that continue to draw researchers’ attention to their disadvantage in maths (Stoet and Geary 2015).

The value of examining the gender gaps in students’ scores lies in at least two areas (i) specifying exactly which group of students is experiencing problems and performing poorly in maths and, (ii) identifying potential relevant support for struggling group(s) of students. From the perspective of gender and maths scholars, applying a gender lens to students’ performance in STEM subjects interrogates and potentially address structural barriers to succeed particularly for girls who have been historically outperformed by boys. Generally in Asian and African developing countries, the gap is explained by differences in women’s role in society as proxied by the fertility rate in a country (Gevrek and Gevrek, 2018).Often associated with reduced career opportunities, gender differences in achievement are high-risk issues.

At the tertiary level in Samoa specifically at the National University of Samoa (NUS), one of the compulsory requirements for undertaking studies in science, IT or mathematics regardless of their major, is a pass in SSLC Mathematics as this would allow students to enrol in the Foundation Certificate of Science. Bridging courses however are available on offer for students with a SSLC maths pass of between 40 and 49 who wish to pursue Science, IT or maths majors. While the compulsory requirement (pass in SSLC maths) highlights the significance of a strong mathematics background in pursuing STEM majors at Foundation and degree levels, it is potentially a contributing factor to why students distance themselves from or are afraid of pursuing STEM studies. Other maths courses are also offered as part of the Preliminary Certificate in Technical Vocational Educational and Training program (PCTVET). As noted in the 2021 NUS Calendar, the PCTVET program “aims to provide tailor made second chance open formal learning opportunities to the disadvantaged youth and adults who intend to pursue further studies at the Post School Education and Training (PSET) level in Samoa.” Potential students for the program should possess at least Year Ten English and Maths. Maths results for PCTVET however are not included in this study.

In this analysis, there are two areas of focus and interest: a persistent imbalance in Foundation enrolment numbers favouring girls and, a more interesting situation with performance outcomes of boys and girls as indicated by 2015-2019 maths scores.

Findings that point to the dynamics of the above areas of focus are derived from a combination of data reading, my own experience as a maths educator and statistical tests and analysis. Given its limited scope using secondary data only, the analysis is exploratory. As such any conclusions drawn would be preliminary and speculative. This however does not invalidate the approach taken and its value in drawing attention to the gendered nature of performances in maths. As an exploratory work, this analysis also serves as an impetus to future in-depth investigations on the subject.

Methodology

Data

The analysis uses sets of secondary data of Foundation students' enrolment numbers and final scores in maths and statistics courses between 2015 and 2019. The courses are: HMA010, HMA020, HMA030, HMA071, HMA072 and HST050[1]. Enrolment numbers and a breakdown of marks by gender were obtained from the NUS Student Administration Office. A five-year focus was determined by the available yearly data that can provide some indication of the gender gaps in maths. It is hoped that the 2015-2019 data would provide a window of possibilities for future in-depth research.

Analysis

The analysis focuses on the gender gaps in Foundation program enrolment numbers and in the performances as indicated by maths scores. Enrolments can indicate what the gender gap looks like with raw numbers. Performances can reveal another side of the gender gap that enrolments alone do not show. As a caveat, however, the presence of the gender gaps should be read as just that. This is because examining factors influencing the gender gaps is beyond the scope of this analysis.

The analysis was guided by the three research questions: *What do the gender gaps in students marks in maths look like? What do the gender gaps in maths scores suggest? What are the implications of the gender gaps for future research?* The analysis had three steps. First, a straight-forward reading of the gender differences by enrolment was made using raw enrolment data provided by the NUS Student Administration Office. The enrolment numbers used included all students enrolled at the beginning of each semester for the five years. Students with a final grade of W, DNC and DNS were excluded from the analysis[2]. Second, a reading of students' scores using the provided gender-based data was done to identify the gender gaps in the pass rates and failure rates for the five-year period. In maths the pass mark is 50/100 and above. The pass rate for girls in each maths course per year was calculated by adding the total number of girls who passed divided by the total number of girls in the course. The same process was followed in calculating the pass rate for boys.

The third part of the analysis aims to confirm the *extent* of gender-based differences in maths scores by course and by program. Statistical testing was applied using the Real Statistics Resource Pack Tool on Excel. In the analysis, maths scores represent students' performances. Thus, gender-

[1] HMA010- Foundation Algebra; HMA020- Foundation Calculus; HMA030-Foundation mathematics; HMA071-Foundation General Maths 1; HMA072- Foundation General Maths 2; HST050-Foundation Statistics

[2] W=withdrawn; CR=Credit; DNC=Fail:Did not complete 10 percent or more of coursework; DNS=Fail: Did not sit exam

differences in scores represent the differences in the performance of boys and girls across the courses or programs. Generating a descriptive statistics report was done for over 3800 student marks from the six math courses across the five-year period. Descriptive statistics confirms the difference in the mean scores of males and females and includes standard deviation, variances and confidence intervals. To establish the significance of gender-based differences indicated by the mean scores, inferential statistics was generated using t-test, one-way ANOVA and two-way ANOVA. The findings and discussion for both enrolment numbers and marks analysis are presented in the next section.

Results and Discussion

***What do the gender gaps in student numbers in maths look like*?**

Reading of Enrolment Numbers

There were consistently more females than males enrolled in our main Foundation maths and statistics courses over the five-year period as shown in Table 1. This mirrors a similar trend for all program enrolments at the NUS as demonstrated in Table 2. As noted in existing studies, the overall dominance of female enrolment at the NUS is likely a ripple effect of national schools' enrolments particularly at the high school level.

Table 1: Foundation maths courses enrolment numbers by gender, 2015-2019

Gender	**2015**	**2016**	**2017**	**2018**	**2019**
Female	448	430	297	290	292
Male	237	231	134	137	127
Grand Total	**696**	**661**	**431**	**427**	**419**

Table 2: Total NUS enrolment numbers by gender, 2015 - 2019

Gender	**2015**	**2016**	**2017**	**2018**	**2019**
Female	2011	2209	2204	2146	1679
Male	1351	1340	1206	1194	871
Grand Total	**3362**	**3549**	**3410**	**3340**	**2550**

Despite female dominance in NUS enrolments, data disaggregated by program indicates that apart from Foundation and degree levels, much higher male enrolment numbers are a common feature of PCTVET programs. Table 3 shows an example of this for 2016 and 2018 academic years. Certificates offered at PCTVET focus on marine studies, welding, automotive, construction, machinery and plumbing continue to be male dominated. However as mentioned earlier, entrance in these certificate programs require at least Year 10 maths background.

Table 3. Selected PCTVET program enrolments by gender, 2016 and 2018

	2016		2018		
Trade Certificate	**Female**	**Male**	**Females**	**Males**	
NatTradeCertIIWel	2	12		10	Welding
NatTradesCertIIAut		20	1	14	Automotive
NatTradesCertIICJ		19	2	11	Construction & Joinery
NatTradesCertIIEl		7		6	Electrical
NatTradesCertIIFM	1	10		6	Fitting & Machining
NatTradesCertIIPl		13		2	Plumbing
NatTradesCertIIRA	2	16		7	Refrigeration & Aircon
Certificate					
CertIIMarTrain	1	6		5	Maritime Training
CertIIMarTrain(ME)	1	23	4	24	
CertIIMarTrain(N)	5	81	14	79	
CertQualFishingDeckHand,	1	18		19	
CertTropHort	12	14	16	6	
Diploma					
DipRad&El	4	14	7	11	Radio & Electronics
TOTALS	**29**	**253**	**44**	**200**	

Although females enrolments dominate across the Arts, Commerce, Education and Nursing degree programs, their numbers are much lower in Science and TVET degree programs (Table 4). This reduction in female numbers gives a glimpse of how female students tend to drop out of typically STEM-programs and courses as they progress from foundation to degree levels. Proving this point however is beyond the scope of this analysis.

Table 4. Some Bachelor degree program enrolments by gender, 2015-2019

	2015		2016		2017		2018		2019	
Programs	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**
BA	122	64	135	64	135	72	138	67	137	67
BCom	239	115	279	116	296	114	271	114	305	113
BEd(Pry)	196	65	271	80	346	94	326	87	285	74
BEd(Sec)	124	82	131	84	99	64	62	36	37	25
BN	131	28	169	70	203	69	179	61	154	52
BSc	65	69	67	82	74	82	58	72	56	54
BSc(SecTchg)	2	7	6	17	6	13	1	9	2	2
BSS	1	6	6	10	8	17	8	16	9	17
BTVET	3	4	3	5	3	15	0	16	1	11

Reading of Foundation Math Courses Enrolment Numbers

Foundation program enrolments by gender are given in Table 5. The data shows that overall FCG recorded the highest student numbers between 2015 and 2019, ranging between 111 to 386, with an average of 241 students. The second highest program was FCA with enrolments between 100 and 200, and an average of 152 students. In the same period, female students outnumbered males by roughly an average of about 35%. The third highest student numbers were in FCS with an average of 120 students, followed by FCE with an average of 113 students. Followed closely behind these was FCC with an average enrolment of 93, and FCN with an average enrolment of 90 students. Except for FAg, the average enrolments of female students outnumbered males in all programs in the five-year period.

Table 5. Foundation program enrolments by gender, 2015 - 2019

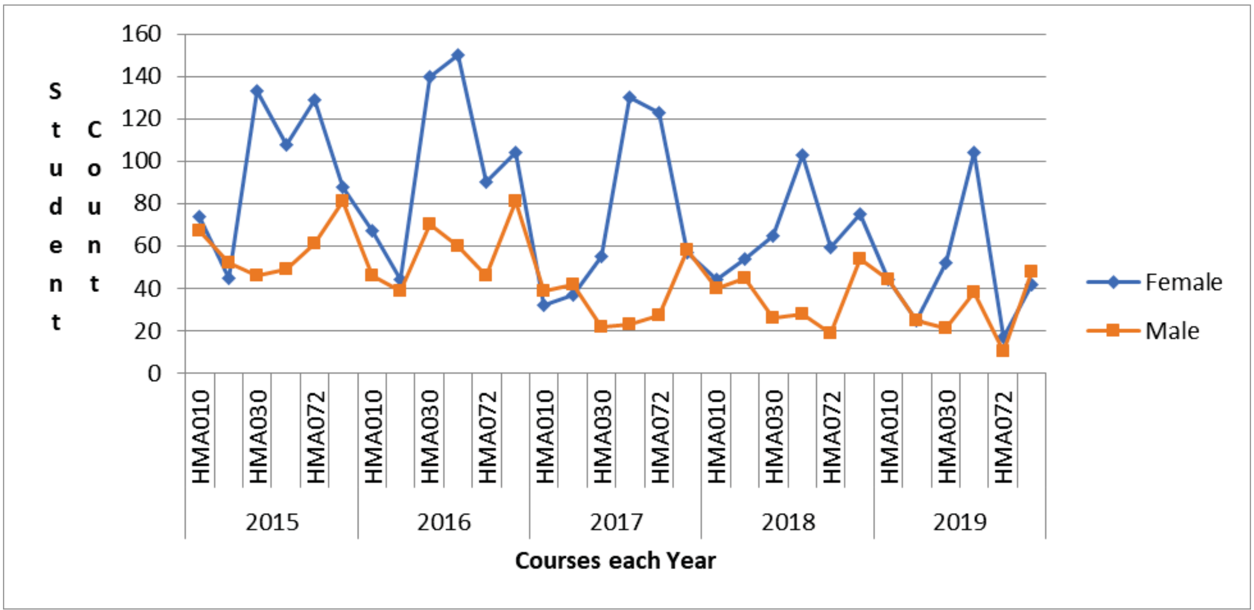
	2015		2016		2017		2018		2019	
Program	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**
FCA	128	45	127	72	72	27	101	43	129	40
FCAg	6	7	1	4			1			1
FCC	113	24	80	24	60	16	70	27	39	17
FCE	163	82	160	75	23	7	31	7	17	8
FCG	63	48	138	83	254	132	220	127	102	64
FCN	85	32	71	17	57	24	74	19	52	17
FCS	78	70	87	65	50	41	65	53	50	48
Total	**636**	**308**	**664**	**339**	**516**	**247**	**562**	**276**	**337**	**141**

In terms of enrolment numbers in maths and statistics courses, there is no doubt that female numbers are higher as shown in Figure 1. Three courses with consistently higher numbers of female students across the five-year period were HMA030, HMA071 and HMA072. When aligned to program enrolments for each year, it appears that relatively large enrolments in FCG and FCA would have had greatly influenced the numbers in the three courses. Also, all FC (Education) students would have enrolled in HMA071 and HMA072 given that the two courses are compulsory for the program. The two are also electives for FCG. HMA030 is an elective course for FC (Commerce), and if students in these programs also took maths thus influencing higher numbers in this course.

By comparison, the HMA010, HMA020 and HST050 courses experienced similar male and female student numbers across the five years, with each course's total enrolment numbers featuring much less than those for HMA030, HMA071 and HMA072. Nonetheless, female numbers continued to exceed males in all of the six courses. HMA010, HMA020 and HST050 are necessary electives for students to graduate in FC (Science) and FC (Commerce) – two of the few programs with enrolment numbers fluctuating between 55 and 90 in the five-year period.

Besides the overall dominance of female students as a key influencing factor in maths enrolment gender gaps, not much is known about other possible factors. From my own view as a maths educator, girls' increased interest in maths and related subjects, advanced reading and literacy abilities, and parental support through provision of paid maths tutoring services in high school levels could be possible determinants. However, as noted before, these require primary research to ascertain.

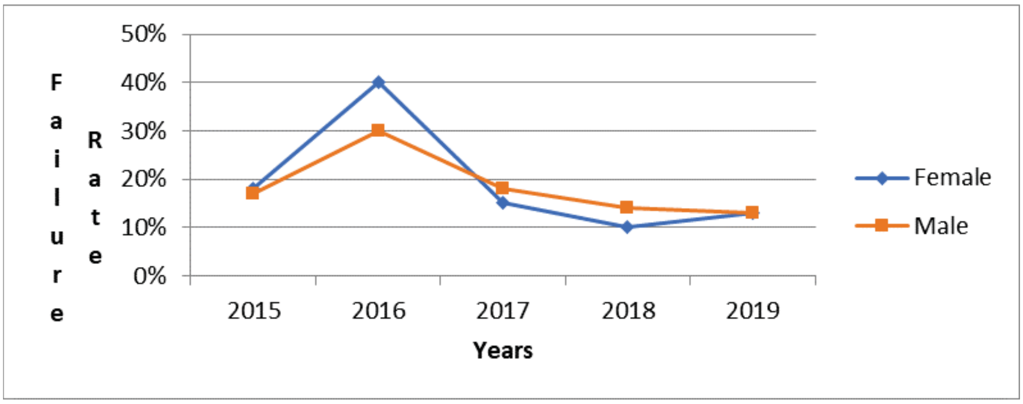
Figure 1. Foundation maths and statistics enrolment counts by gender, 2015-2019



What do the gender gaps in maths scores suggest?

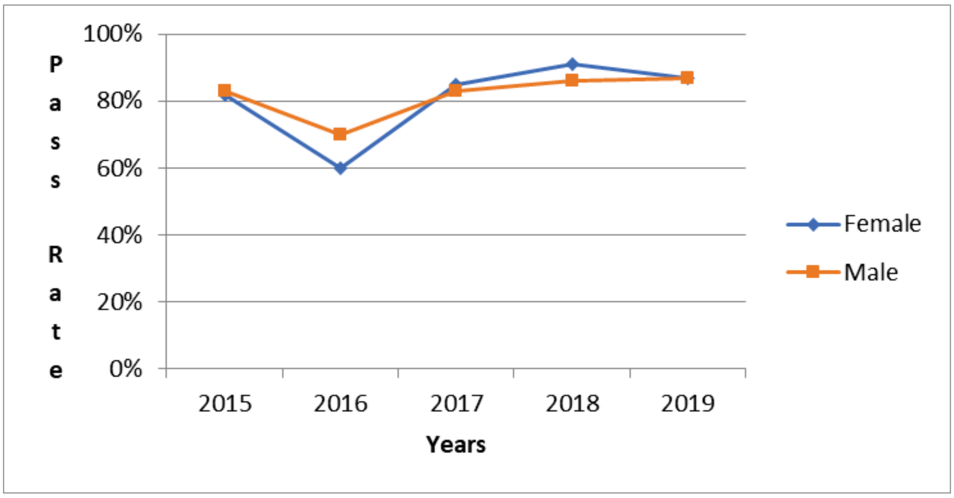
To answer the second research question, the gender-gaps in performances are examined. Taking only raw numbers of failing and passing students reveal the results as shown in Figure 2. On average for the five-year period, the failure rate for female students is 19%. This means that of all females enrolled in foundation Maths across the 5 year period, 19% of them fail compared to 18% of male students. A one percent gap is detected here. This result suggests that with more females taking maths, more of them are also failing compared to male students.

Figure 2: Failure rates in all Foundation maths courses by gender, 2015-2019



In terms of the pass rate, the average for the five years was 81% for females and 83% for males. These are encouraging results which suggest that the majority of our students are passing maths at foundation level. It also shows that the pass rate of 2% marks a narrow gender differences in performance with a marginal lead by males.

Figure 3: Pass rates in all Foundation maths courses by gender, 2015 - 2019



Applying Statistical Analysis to Confirm the Initial Results

As seen above, a straight-forward reading of students' marks shows that the gender gaps do exist in student performances. But how significant is the gender gaps? To answer this question, statistical tests and analysis were conducted and an alpha level of .05 was used across the tests.

a. Determining the significance of means difference by Gender only.

Generating a descriptive statistics report was done for about 3800 student marks from the six math courses across the five-year period. As in Table 6, a difference in mean mark values is shown with females' average mark of 59.64 with a 95% confidence interval(CI) of [58.73, 60.55]. The average mark for males sits at 62.80 with a 95% CI of [61.92, 63.68]

Table 6: Descriptive Statistics

females		*males*	
Mean	59.64105	Mean	62.8026316
Standard Error	0.464326	Standard Error	0.4475893
Median	60	Median	63
Mode	50	Mode	50
Standard Deviation	20.2395	Standard Deviation	19.5099654
Sample Variance	409.6373	Sample Variance	380.63875
Kurtosis	-0.44833	Kurtosis	-0.3162233
Skewness	-0.28063	Skewness	-0.3527246
Range	99	Range	93
Minimum	0	Minimum	6
Maximum	99	Maximum	99
Sum	113318	Sum	119325
Count	1900	Count	1900
Confidence Level(95.0%)	0.910643	Confidence Level(95.0%)	0.8778184

b. Applying a t-Test

The gender gap in mean marks identified in the descriptive statistics does not tell if the gap is of significance. To confirm this, it was necessary to perform a t-Test. The test takes the null hypothesis that the females and males mean marks are the same. The alternative hypothesis is that the mean values differ. The test produced the results in Table 7.

Table 7. tTest Results

t-Test: Two-Sample Assuming Equal Variances		
	females	*males*
Mean	59.64105263	62.80263158
Variance	409.6372817	380.6387503
Observations	1900	1900
Pooled Variance	395.138016	
Hypothesized Mean Difference	0	
df	3798	
t Stat	-4.902204521	
P(T<=t) one-tail	4.93647E-07	
t Critical one-tail	1.645254928	
P(T<=t) two-tail	9.87293E-07	
t Critical two-tail	1.960588791	

The t-Test results confirm the mean marks from the descriptive statistics and as the p-value of 0.00 (two-tailed) is less than .05, the null hypothesis is rejected. This highlights there is a significant gender-based difference in Foundation maths performance with males having a higher mean score.

c. Applying a One-way ANOVA

A gender gap is prominent from the t-Test but perhaps the courses that students took may have also influenced their final mark. A one-way ANOVA was performed to compare student mean marks across the Foundation math courses. A Tukey's HSD test was included as part of the ANOVA, to highlight which courses differ significantly. The ANOVA takes on the null hypothesis that there are no differences in the mean marks across the courses, while the alternative states there is a difference in the mean values for at least two courses. The results are shown in Table 8.

Table 8: One-way ANOVA & Tukey's Test to compare mean marks by courses

ANOVA: Single Factor

DESCRIPTION — Alpha 0.05

Group	Count	Sum	Mean	Variance	SS	Std Err	Lower	Upper
HMA010	150	9564	63.76	395.8212	58977.36	1.667008	60.48829	67.03171
HMA020	150	9239	61.59333	468.1355	69752.19	1.667008	58.32163	64.86504
HMA030	150	9282	61.88	437.0325	65117.84	1.667008	58.60829	65.15171
HMA071	150	5992	39.94667	439.3394	65461.57	1.667008	36.67496	43.21837
HMA072	150	7591	50.60667	392.361	58461.79	1.667008	47.33496	53.87837
HST050	150	9952	66.34667	368.3354	54881.97	1.667008	63.07496	69.61837

ANOVA

Sources	SS	df	MS	F	P value	Eta-sq	RMSSE	Omega Sq
Between Groups	76335.49	5	15267.1	36.62602	3.39E-34	0.170017	0.494139	0.165221
Within Groups	372652.7	894	416.8375					
Total	448988.2	899	499.4307					

TUKEY HSD/KRAMER — alpha 0.05

group	mean	n	ss	df	q-crit
HMA010	63.76	150	58977.36		
HMA020	61.59333	150	69752.19		
HMA030	61.88	150	65117.84		
HMA071	39.94667	150	65461.57		
HMA072	50.60667	150	58461.79		
HST050	66.34667	150	54881.97		
		900	372652.7	894	4.03

Q TEST

group 1	group 2	mean	std err	q-stat	lower	upper	p-value	mean-crit	Cohen d
HMA010	HMA020	2.166667	1.667008	1.299734	-4.55138	8.88471	0.941665	6.718044	0.106123
HMA010	HMA030	1.88	1.667008	1.127769	-4.83804	8.598044	0.967957	6.718044	0.092082
HMA010	HMA071	23.81333	1.667008	14.28507	17.09529	30.53138	1.87E-13	6.718044	1.166371
HMA010	HMA072	13.15333	1.667008	7.890383	6.43529	19.87138	4.78E-07	6.718044	0.644247
HMA010	HST050	2.586667	1.667008	1.551682	-4.13138	9.30471	0.882555	6.718044	0.126694
HMA020	HMA030	0.286667	1.667008	0.171965	-6.43138	7.00471	0.999996	6.718044	0.014041
HMA020	HMA071	21.64667	1.667008	12.98534	14.92862	28.36471	1.87E-13	6.718044	1.060248
HMA020	HMA072	10.98667	1.667008	6.590649	4.268623	17.70471	5.33E-05	6.718044	0.538124
HMA020	HST050	4.753333	1.667008	2.851415	-1.96471	11.47138	0.333767	6.718044	0.232817
HMA030	HMA071	21.93333	1.667008	13.1573	15.21529	28.65138	1.87E-13	6.718044	1.074289
HMA030	HMA072	11.27333	1.667008	6.762614	4.55529	17.99138	2.99E-05	6.718044	0.552165
HMA030	HST050	4.466667	1.667008	2.679451	-2.25138	11.18471	0.406054	6.718044	0.218776
HMA071	HMA072	10.66	1.667008	6.394689	3.941956	17.37804	0.000101	6.718044	0.522124
HMA071	HST050	26.4	1.667008	15.83675	19.68196	33.11804	1.87E-13	6.718044	1.293066
HMA072	HST050	15.74	1.667008	9.442064	9.021956	22.45804	6.44E-10	6.718044	0.770941

The ANOVA reveals that there is a statistically significant difference in student performances between at least two courses as the p-value is 0.00. The Tukey's HSD Test for multiple comparisons found nine pairing comparison with significant mean difference. For example, the mean value of student marks was significantly different between HMA010 & HMA071 (p = 0.00, 95% C.I. =17.10, 30.53), HMA010 & HMA072 (p = 0.00, 95% C.I. =6.44, 19.90), HMA020 & HMA071 (p=0.00, 95% C.I. = 14.92, 28.36) and other courses as marked in the above Tukey's report.

There are however no statistically significant differences between HMA010 and HMA020 (p=0.94), HMA010 and HMA030 (p=0.97), HMA010 & HST050 (p= 0.88), HMA020 & HMA030 (p = .99), HMA020 & HST050 (p= 0.33), and HMA030 & HST050 (p= 0.41).

d. Applying a two-way ANOVA test with Gender and Course

Student marks were also submitted to a two-way ANOVA with 5 levels of courses, and two levels of gender and the below report was produced. The two-way ANOVA starts with the hypotheses that:

- There are no differences among gender mean marks
- There are no differences among the course taken mean marks
- There is no interaction between gender and courses taken.

The results are shown in Table 9.

Table 9: Results of a two-way ANOVA : Mean mark versus Gender, Courses

Descriptive Statistics							
COUNT	balanced						
	HMA010	HMA020	HMA030	HMA071	HMA072	HST050	
females	160	160	160	160	160	160	960
Males	160	160	160	160	160	160	960
	320	320	320	320	320	320	1920
MEAN							
	HMA010	HMA020	HMA030	HMA071	HMA072	HST050	
females	62.34375	64.61875	53.1125	39.98125	50.6875	71.225	56.99479
Males	63.31875	64.1	57.64375	53.525	62.89375	67.9	61.56354
	62.83125	64.35938	55.37813	46.75313	56.79063	69.5625	59.27917
VARIANCE							
	HMA010	HMA020	HMA030	HMA071	HMA072	HST050	
females	461.4723	486.5141	399.5344	372.8613	373.2099	337.2824	508.7351
Males	364.6713	497.9145	325.8283	525.3075	410.2717	360.1912	433.7978
	412.0153	490.7388	366.6936	493.6787	427.8777	350.4161	476.242

Two Factor Anova						
ANOVA				Alpha	0.05	
	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Rows	10019.27	1	10019.27	24.46181	8.24E-07	0.012658
Columns	103195.3	5	20639.07	50.3898	3.67E-49	0.116646
Inter	19199.39	5	3839.879	9.374973	7.73E-09	0.023978
Within	781494.4	1908	409.5882			
Total	913908.4	1919	476.242			

The two-way ANOVA results suggest that the main effect gender was significant with p = .00, meaning that the mean value mark for females (M = 56.99) was significantly less than that for males (M = 61.356). The main effect of maths courses was also significant, with p = .00. Both factors therefore have a significant effect on the results of the students and thus we can reject the null hypothesis for both factors. The interaction was significant as well, with p = .00, suggesting that the effect of gender was significant across the various courses. The null hypothesis for the interaction was rejected and this suggests that gender and courses do have a combined effect on student performances.

e. Applying a two-way ANOVA test with Gender and Program

Another two-way ANOVA test was carried out to determine if gender and program have significant impact on students' performance (Table 10). The programs with the most numbers of maths students were selected for this test.

Table 10: Two-way ANOVA : Mean mark versus Gender, Programs

Descriptive Statistics

COUNT	balanced				
	FCC	FCE	FCG	FCS	
females	150	150	150	150	600
Males	150	150	150	150	600
	300	300	300	300	1200

MEAN					
	FCC	FCE	FCG	FCS	
females	61.24	35.54	49.19333	60.11333	51.52167
Males	65.12667	48.24	53.06667	62.68	57.27833
	63.18333	41.89	51.13	61.39667	54.4

VARIANCE					
	FCC	FCE	FCG	FCS	
females	447.1098	322.1695	294.6	432.8126	479.7525
Males	307.3597	486.3984	344.7606	356.0983	419.4132
	379.7623	443.3892	322.3743	394.7886	457.4996

Two Factor Anova

ANOVA Alpha 0.05

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Rows	9941.763	1	9941.763	26.5884	2.95E-07	0.021819
Columns	87987.99	3	29329.33	78.43879	2.61E-46	0.164866
Inter	4907.237	3	1635.746	4.374662	0.004513	0.01089
Within	445705	1192	373.9136			
Total	548542	1199	457.4996			

From the above results, the p-value for gender (rows) was .00 thus the effect of gender is considered statistically significant. There were differences between gender means with females have a lower mean mark (M=51) than males (M=57 test confirms a significant difference.. For programs (columns), the p-value is also .00 indicating a significant difference between program means for females, ranging from 35 for FCE, to 61 for FCC, and for males ranging from 48 for FCE to 65 for FCC For the interaction term (Inter), its p-value of .0045 reflects a significant interaction between gender and programs on student final marks.

The results also provide a glimpse into potentially complex dynamics underpinning gender-based performances in Foundation-level maths. Part of this dynamics constitutes variations in the gender gaps defined by two main trends – one where girls dominate enrolment numbers and number of passes per course, and another where boys dominate overall performance in terms of scores. The first trend validates a common narrative in the literature of females outnumbering boys and leading to concerns about a 'boy crisis' in Samoa (Government of Samoa, 2020). The second pattern of males scoring higher than girls indicates that despite their lower numbers, male students continue to excel in maths. This however seems to be a less-known 'story' that is overshadowed by a dominant narrative about girls outnumbering and outperforming boys in Samoa's schools and tertiary education.

What are the implications of the gender gaps for future research?

The above results point to the need for more research into gender-based performances in tertiary-level maths. There are important reasons for this. One is that it is not enough for educators and policy makers to focus on results of analysis based on aggregated data on students' maths performance. Not all students are the same, and by applying a gender lens, one can appreciate the differences that characterise the performances of boys and girls. Globally there is evidence that maths is experienced differently by boys and girls and, depending on the context, different patterns of performances can be observed (Cook, 2018). In Samoa, there is limited research on this thus scrutinising scores by gender can help provide a deeper understanding of students' performances in and experiences of maths.

The scope of this study limits it to using secondary data. The results have implications for deeper and broader analysis in the future. Qualitative research focused on factors influencing the performances and experiences of male and female students is needed. Relevant interventions to support male and female students learning of maths can be derived when more and clearer evidence is available through qualitative research. At the same time, quantitative analysis could focus on bigger datasets potentially including more NUS courses and programs. These would produce statistically valid and significant findings to also inform potential policy and intervention programs.

The study also has implications for future research focused on completion rates of female and male students in degree level programs. Table 4 gives a glimpse into much lower female enrolment in science and maths degree programs at NUS. This can be regarded as a tip of the iceberg situation as underlying factors responsible for a consistently lower female numbers are not known. Concerns about these patterns include possible lower completion rates among females leading to lower chances of employment in STEM related fields. Overall, the call for more research on possible causes of existing trends of gender-based achievements in maths is timely and necessary.

Conclusion

This exploratory analysis sets out to answer three questions related to the gender gaps in student numbers and performances in Foundation maths courses. Significant gender gaps exist with enrolment and pass rates consistently dominated by females. While this situation verifies the already existing narratives about girls outnumbering boys, the factors causing this have not been researched. The view that this pattern at the Foundation mirrors that at high school level is widely acknowledged. However, this cannot be the sole influencing factor, thus the need for research is critical.The dominance of boys in overall achievements in maths could serve to restore confidence in their academic ability. To some extent, it raises questions about how performance is measured. Reference to pass rates by gender does not tell the whole story as the outcomes of statistical tests indicate. Given the dominance of boys in maths scores producing an opposite situation to commonly held views, research is also needed to establish firm evidence to inform relevant policy.

This study fills part of knowledge gaps related to the gendered nature of maths performances. Although there is limited literature on the Samoa situation, potential for both qualitative and quantitative analyses is unlimited. For relevant policy to exist, it is critical to unearth more evidence on the gendered nature of performances in maths, implications for university studies completion, and justified employment opportunities for both males and females.

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References

Afamasaga-Fuata'i. Karoline. 2002. 'A Samoan Perspective on Pacific Mathematics Education', in, Barton, B; Irwin, K. C.; Pfannkuch, M, and Thomas, M.O. (Eds.) *Mathematics Education in the South Pacific* (Proceedings of the 25th annual conference of the Mathematics Education Research Group of Australasia, Auckland, pp. 1-13). Sydney: MERGA.

Cappenlen, Alexander W., Ranveig Falch and Bertil Tungodden, 2019 *The Boy Crisis: Experimental Evidence on the Acceptance of Males Falling Behind,* DISCUSSION PAPER Institutt for samfunnsøkonomi Department of Economics. https://www.nhh.no/en/research-centres/fair/news/2019/march/the-boy-crisis-experimental-evidence-on-the-acceptance-of-males-falling-behind/. Accessed 3 May 2021

Cook, Diane. 2018. 'The gender gap in maths is not universal', https://chance.amstat.org/2014/11/visiphilia/. Accessed 23 April 2021

Forgasz, Helen, J. and Leder, Gilah. 2017. 'Persistent gender inequities in mathematics achievement and expectations in Australia, Canada and the UK', *Mathematics Education Research Journal* 29:261–282 DOI 10.1007/s13394-017-0190-x

Gevrek, Z. Eylem and Gevrek, Deniz. 2018. *Explaining the Gender Test Score Gap in Mathematics: The Role of Gender Inequality.* DISCUSSION PAPER SERIES IZA DP No. 11260 . Católica Porto Business School Christian Neumeier University of Konstanz, http://ftp.iza.org/dp11260.pdf. Accessed 3 May 2021

Gill, Judith. 1997. 'Mathematics and gender: Beyond rational numbers?', *Mathematics Education Research Journal* 9 (3): 343-346

Government of Samoa. 2020. *Samoa's Second Voluntary National Review on the implementation of the Sustainable Development Goals.* http://www.spc.int/DigitalLibrary/Doc/SDD/Sustainable_Development_Goals__SDGs/VNRs/Samoa_VNR_2020.pdf Accessed: 5 May 2021

Hill, C.; Corbett, C. and St Rose, A. 2010. *Why so few? Women in Science, Technology, Engineering and Mathematics*, American Association of University Women, Washington DC. https://ww3.aauw.org/research/why-so-few/. Accessed: 3 May 2021

Lee, Valerie E., and David T. Burkam 1996. "Gender Differences in Middle-Grade Science Achievement: Subject Domain, Ability Level, and Course Emphasis." *Science Education* 80:613–50.

Marginson, S.; Tytler, R.; Freeman, B. and Roberts, K. 2013. *STEM: Country Comparisons: International Comparisons of Science, Technology, Engineering and Mathematics (STEM) Education.* Final report. Australian Council of Learned Academies, Melbourne, Vic. https://dro.deakin.edu.au/view/DU:30059041. Accessed: 3 May 2021

Mullet, D. R. and Kettler, T. 2017. 'Catalysts of Women's Talent Development in STEM: A Systematic Review' *Journal of Advanced Academics* 28(4) 253–289 DOI: 10.1177/1932202X17735305

Myers, K.; Gallaher, C. and McCarragher, S. 2019. 'STEMinism', *Journal of Gender Studies* 28 (6): 1-3. DOI: 10.1080/09589236.2019.1584744

Przybyla-Kuchek, J. 2020. 'The possibilities of feminist poststructural discourse analysis as an approach to gender research in the mathematics classroom'. *Mathematics Education Research Journal* https://doi.org/10.1007/s13394-020-00364-5

Stoet, G., and Geary, D. C. 2015. 'Sex Differences in Academic Achievement are Not Related to Political, Economic, or Social Equality.' *Intelligence* 48: 137–151. doi:10.1016/j.intell.2014.11.006

The National University of Samoa. 2020. *Calendar 2021*. NUS, Toomatagi.

Von Stumm, S.; Hell, B. and Chamorro-Premuzic, T. 2011. 'The hungry mind: intellectual curiosity is the third pillar of academic performance', *Perspectives on Psychological Science* 6(6): 574-588 doi.org/10.1177/1745691611421204