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GENDER DISPARITIES OF FILIPINO GENERATION Z LEARNERS IN MATHEMATICS

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Abstract:

This study explores the gender disparities of Gen Z Filipino learners in mathematics along with math anxiety, math self-concept and math self-efficacy as the focal point. It considers as samples the first graduates of the K–12 curriculum in the Philippines who completed their twelve-year basic education in 2018. Findings were compared to other studies to identify the uniqueness, similarities and differences of the Gen Z local samples when compared to the Gen Y and Gen Z students from the global communities. Figures were analyzed using the one-proportion z-test in comparing the observed and hypothesized proportions and the two-proportion z-test in comparing the observed proportions of sample males and females. Statistics revealed that sample females have higher level of anxiety; while males expressed greater self-efficacy. Though sample males have stronger self-concept but the difference indicates no significance. Gender disparities in math anxiety and math self-efficacy can be attributed to the proportions displayed by the sample females which are afar from the results of previous investigations. Data analysis along with the cited studies, provide insights that the biological, psychological and social factors have vital roles in the development not only of one's concept and efficacy but also of anxiety in math. As the theories said, learning happens with a dynamic and shared interaction of the person, the behavior, and the environment where people can feel the sense of acceptance, empathy and genuineness. The study offers recommendations to the influential actors in the learners' lives to address the gender gaps.

Key Words: Gender Disparity, Generation Z, Math Anxiety, Math Self-Concept, Math Self-Efficacy & Mathematics

Introduction:

With the birth of the new generation (Generation Z or Gen Z) who are known to be the most technologically literate and socially empowered age group of learners, the learning environment significantly changed. The effective classroom engagement of students and teachers has shifted from verbal to visual with the presence of advanced digital devices. The source of information used in learning has progressed from a textbook type to an open book platform with few clicks away to be connected globally. The role of the educator has transformed from the traditional teacher model to a facilitator of learning. The adoption of curriculum centred before has moved to a learner centred curriculum.

Abreast these major changes, the gender gaps of learners have been continuously observed globally. The UNESCO Institute for Statistics (UIS) has promised to close the gender disparities by 2030 [1]. According to UIS, "girls are still more likely than boys to never set foot in a classroom, despite the tremendous progress made over the past twenty years". In higher education, the UIS tracks female and male students by fields of study, with utmost concern in the fields of Science, Technology, Engineering and Mathematics (STEM).

Involving different generations, most studies came out with similar findings that gender differences in the academic performance of learners are widely observed in the school settings. Moreover, sources worldwide disclosed significant gender gaps not only on students' performance, but also on the learners' characteristics such as anxiety, self-concept and self-efficacy. In this context and in support to the trust of the UIS, the researcher opted to explore on gender disparities involving local samples of Filipino Gen Z learners in higher education and likewise consider the students' anxiety, self-concept and self-efficacy in math as the main variables of the study.

Literature Review:

To grasp well the discussions on the gender gaps of the sample Filipino Gen Z learners in math, this study used the findings of the Programme for International Student Assessment (PISA) in 2003 and 2012 for purposes of comparison as regard to learners' math anxiety, math self-concept and math self-efficacy. During the said years, PISA covered math as their main focus in the assessment. Two periods were intentionally included in the literature as well as in the analysis to compare the local Filipino Gen Z samples to the Gen Z and Gen Y students globally.

Literature said that birth years of Gen Z starts in 1996 while Gen Y (also known as Millennial) birth years fall from 1977 to 1995 [2]. Gen Z is the most connected, educated and sophisticated generation ever [3]. The

deep integration of digital communications into the lives of Gen Z brings wider benefits in connection, social action and self-expression, but also has its own risks according to source [4].

PISA in 2003 covered over a quarter of a million students 15-16 years old from the 41 participating countries [5]. They were born earlier than 1996, thus they belong to Gen Y; while PISA in 2012 involved more than half a million of students 15-16 years old from the 65 participating countries and economies [6]. They were born later than 1996, thus belonging to Gen Z.

Figures presented in the succeeding discussions pertaining to the three variables (math anxiety, math self-concept and math self-efficacy) are based on the average figures reported among the Organization for Economic Cooperation and Development (OECD) countries in PISA 2003 and 2012.

Gen Y Gender Disparities in Math:

Among the Gen Y students in 2003, a substantial proportion reported the feelings of math anxiety (40.70%), math self-concept (46.66%), and math self-efficacy (71.06%) [5]. Females have higher levels of math anxiety; while males expressed stronger math self-concept and greater math self-efficacy.

The associations of math performance of female Gen Y with each of the three variables (math anxiety, math self-concept and math self-efficacy) constantly indicate significant relationships. Math performance exhibited moderate negative correlation (–0.35) with math anxiety; while moderate (0.37) and strong (0.51) positive correlations with math self-concept and math self-efficacy, respectively [5].

Likewise, the correlations of math performance of male Gen Y with each of the three said variables consistently imply significant relationships. Math performance posted moderate negative correlation (–0.34) against math anxiety; while moderate (0.36) and strong (0.51) positive correlations against math self-concept and math self-efficacy, respectively[5].

Gen Z Gender Disparities in Math:

Along with the Gen Z students in 2012, a considerable proportion had the feelings of math anxiety (42.68%), math self-concept (48.36%), and math self-efficacy (72.18%) [6]. Similar to Gen Y, the Gen Z females expressed higher levels of math anxiety and Gen Z males have stronger math self-concept and greater math self-efficacy.

The correlations of math performance of female Gen Z with each of the three variables consistently show significant relationships which followed the same trend as Gen Y. Math performance disclosed moderate negative correlation (–0.36) with math anxiety; while moderate (0.41) and strong (0.54) positive correlations with math self-concept and math self-efficacy, respectively [6].

Similarly, the associations of math performance of male Gen Z with each of the three variables constantly demonstrate significant relationships. Math performance revealed moderate negative correlation (–0.36) against math anxiety; while moderate (0.38) and strong (0.52) positive correlations against math self-concept and math self-efficacy, respectively [6].

Comparison of Gen Y and Z Learners:

From 2003 to 2012, the math anxiety (from 40.70% to 42.68%), math self-concept (from 46.66% to 48.36%) and math self-efficacy (from 71.06% to 72.18%) generally increased slightly for mixed gender and similarly observed for each group of males and females [5-6].

During the span of time, the gender difference in math anxiety has narrowed. The magnitude of gender gap in math self-concept remained stable. Likewise, math self-efficacy maintained the magnitude of gender disparity[5-6].

Variables as Defined:

Math anxiety refers to the feelings of apprehension and increased physiological reactivity when individuals deal with math, such as when they have to manipulate numbers, solve mathematical problems, or when they are exposed to an evaluative situation connected to math [7]. PISA 2012 defined math anxiety as a feeling of stress and helplessness when dealing with math [6].

Math self-concept is the way an individual thinks, feels, acts, values and evaluates oneself in relation to performance in math [8]. PISA 2012 simply referred math self-concept as perceived competence in math [6].

Math self-efficacy as the literature defined is a situational assessment of one's confidence in her/his ability to successfully perform or accomplish a particular task or problem in math [9]. PISA 2012 considered math self-efficacy as perceived ability to solve a range of pure and applied math problems [6].

Materials and Methods:

The study used the descriptive method of research. This type of research method, aside from gathering and tabulating information, also involves data analysis, interpretation, comparison, and identification of trends.

The "Mathematics Self-Concept, Self-Efficacy and Anxiety Scale" created by Psyc Tests was used as the survey instrument for this study. The scale consists of sixteen items across three subscales (math anxiety, math self-concept and math self-efficacy) rated with 4-point Likert scales: from strongly agree to strongly disagree for math anxiety and math self-concept statements; and from very confident to not very confident for math self-efficacy statements [10]. Permission to use the test content was given for this is a non-commercial research and it is for educational purposes.

Two hundred forty (240) sample students, 120 representing each gender, were asked to evaluate themselves as regard to their math anxiety, math self-concept and math self-efficacy. They are freshman college students who belong to the generation Z.

The test procedure called one-proportion z-test was applied to determine if there is a significant difference in the sample proportions (observed proportions) and the PISA proportions (hypothesized proportions). Also, the two-proportion z-test was used to determine whether the difference between two observed proportions of sample males and females is significant. The variations between the said proportions were tested at 0.05 level of significance which implies that difference will be considered significant if the computed z-value is greater than the critical z-value of 1.96; or if the computed p-value is less than 0.05.

Findings and Analysis:

All Gender Learners' Profile:

To be able to know well the learners' background in this study, their profile is herein discussed. When the survey was administered, the learners' age ranges from 17-18 years old. Their birth years fall beginning year 2000 onwards, hence they belong to Gen Z. These learners are the first graduates of the K–12 curriculum in the Philippines who completed their twelve-year basic education in 2018.

Among the 240 learners of this study, 50% are females and 50% are males; 46.9% are graduates of public secondary schools while 53.1% are products of private secondary schools; 64.5% completed STEM-track while 35.5% finished other academic tracks in high school; and 57.0% pursue STEM-related courses in college while 43.0% enrol in non-STEM courses in college (Figure 1).

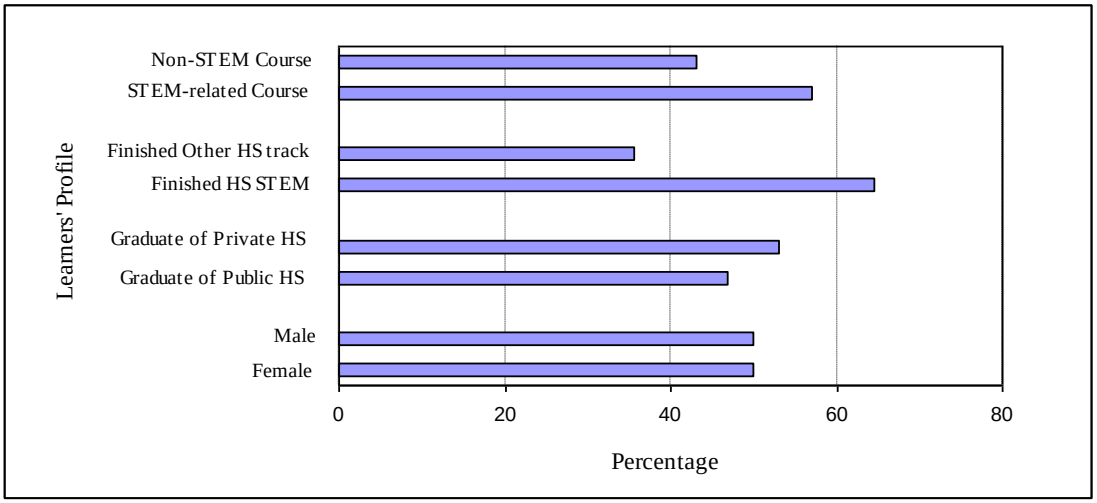

Figure 1: Learners' Profile

Female Learners in Math:

Out of the 120 female respondents, 73.33% (88 females) agree and strongly agree on the math anxiety statements; 40.83% (49 females) agree and strongly agree on the math self-concept statements; and 54.17% (65 females) are confident and strongly confident on the given math self-efficacy statements. Among the three variables, the math anxiety registered the highest proportion which indicates that in general has 7 for every 10 female learners expressed math anxiety. This is followed by math self-efficacy with a ratio of almost 1 for every 2 female learners demonstrated math self-efficacy; lastly, in math self-concept with a share of 2 for every 5 female learners showed math self-concept (Table 1).

Table 1: Females' Anxiety, Self-Concept and Self-Efficacy in Math

Female Samples	Agree/ Strongly Agree *(observed)*	Agree/ Strongly Agree *(hypothesized**)*	z-value	p-value	Interpretation
Math Anxiety	73.33%	42.68%	6.788	<0.0001	Significant
Math Self-Concept	40.83%	48.36%	1.651	0.0988	Not Significant
Math Self-Efficacy	54.17% *	72.18% *	4.403	< 0.0001	Significant

* Percentage with response of confident and very confident

** Source of hypothesized value: PISA 2012 (all genders' response on average of OECD countries)

The sample female respondents displayed higher proportion in math anxiety (73.33%) than in math self-concept (40.83%). This is similar to the results of the studies of Ahmed et al. in 2012, Chaturvedi in 2015,

Malik et al. in 2016, Marusic & Matic in 2017, and Lu et al. in 2017. They concluded in their respective investigations that individuals with higher anxiety tend to have lower self-concept [11-15].

Higher proportion in math anxiety (73.33%) than in math self-efficacy (54.17%) was also demonstrated by female learners. This observation is comparable to the conclusions of Salar et al. in 2016, Razavi et al. in 2017, Unlu et al. in 2017, Asayesh et al. in 2018, and Deer et al. in 2018. They found out that people with higher anxiety are likely to have lower self-efficacy [16-20].

Examining the observed proportions of the three variables, this study further disclosed that female respondents exhibited higher math anxiety, lower math self-concept and lower math self-efficacy. This observation is in agreement with the findings of PISA in 2012, Dobson in 2012, Kvedere in 2014, Jameson & Fusco in 2014, and Raufelder & Ringeisen in 2016. These authors considered the inclusion of the three variables in their respective analysis and found out that higher anxiety complements lower self-concept and self-efficacy [6, 21-24].

To determine if the differences between the observed and hypothesized proportions are significant in this study, the one-proportion z-test was employed. The z and p values revealed that the observed and hypothesized proportions differ significantly in the math anxiety ($z = 6.788$ and $p < 0.0001$) and math self-efficacy ($z = 4.403$ and $p < 0.0001$). Only in the math self-concept that the difference in proportions is not significant ($z = 1.651$ and $p = 0.0988$). Note that the difference in the proportions is considered significant if the computed z-value is greater than the critical z-value set at 1.96 or if the computed p-value is less than 0.05.

These figures indicate that the observed proportion (73.33%) of math anxiety is significantly higher than the hypothesized proportion (42.68%). Moreover, the observed proportion (54.17%) of math self-efficacy is significantly lower than the hypothesized proportion (72.18%). Note that the reported anxiety and self-efficacy of sample females displayed much higher anxiety and much lower self-efficacy compared to the Gen Y (40.70% - math anxiety; 71.06% - math self-efficacy) and Gen Z (42.68% - math anxiety; 72.18% - math self-efficacy) students in PISA 2003 and 2012, respectively.

Male Learners in Math:

Out of the 120 male respondents, 52.50% (63 males) agree and strongly agree on the math anxiety statements; 47.50% (57 males) agree and strongly agree on the math self-concept statements; and 78.33% (94 males) are confident and strongly confident on the given math self-efficacy statements. Among the three variables, the math self-efficacy posted the highest proportion which implies that in general has almost 4 for every 5 male learners reported math self-efficacy. This is followed by math anxiety with a ratio of almost 1 for every 2 male learners displayed math anxiety; lastly, in math self-concept with a share of near 1 for every 2 male learners exhibited math self-concept (Table 2).

Table 2: Males' Anxiety, Self-Concept and Self-Efficacy in Math

Male Samples	Agree/ Strongly Agree *(observed)*	Agree/ Strongly Agree *(hypothesized**)*	z-value	p-value	Interpretation
Math Anxiety	52.50%	42.68%	2.1750	0.0296	Significant
Math Self-Concept	47.50%	48.36%	0.1890	0.8505	Not Significant
Math Self-Efficacy	78.33% *	72.18% *	1.5030	0.1327	Not Significant

* Percentage with response of confident and very confident

** Source of hypothesized value: PISA 2012 (all genders' response on average of OECD countries)

The sample male respondents displayed higher proportion in math anxiety (52.50%) than in math self-concept (47.50%). This also support the findings of Ahmed et al. in 2012, Chaturvedi in 2015, Malik et al. in 2016, Marusic & Matic in 2017, and Lu et al. in 2017. Though they observed as stated earlier that people with higher anxiety tend to have lower self-concept (as also seen in the observed proportions in Table 2), they likewise found out that people with lower anxiety tend to have higher self-concept (as also seen in the hypothesized proportions in Table 2) [11-15].

Lower proportion in math anxiety (52.50%) than in math self-efficacy (78.33%) was also demonstrated by sample male respondents. This also conformed to the conclusions of Salar et al. in 2016, Razavi et al. in 2017, Unlu et al. in 2017, Asayesh et al. in 2018, and Deer et al. in 2018 in their respective studies. Their analysis further disclosed that while higher anxiety leads to lower self-efficacy (as also seen in the sample female proportions in Table 1), lower anxiety leads to higher self-efficacy (as also seen in the sample male proportions in Table 2) [16-20].

Again, employing the one-proportion z-test to determine if the differences between the observed and hypothesized proportions of males are significant, the z and p values were obtained. Figures in Table 2 indicate that the observed and hypothesized proportions have no significant differences in math self-concept ($z = 0.1890$ and $p = 0.8505$) and math self-efficacy ($z = 1.5030$ and $p = 0.1327$); but differ significantly in math anxiety ($z =$

2.1750 and p = 0.0296). Note again that the computed z-values were compared to the critical z-value of 1.96 and p is set significant at values less than 0.05.

Gender Disparities in Math:

Gender disparities as regard to the three variables were measured using the two-proportion z-test. Table 3 shows that significant gender differences were recorded in math anxiety of females (73.33%) and males (52.50%) with z = 3.3409 and p = 0.0008. To examine further the significant difference in math anxiety, the sample proportions were compared to the ratios reported by PISA in 2003 and 2012. Records revealed that in the mixed gender, 40.70% of Gen Y and 42.68% of Gen Z expressed anxiety, which evidently show that the proportion of the sample females of 73.33% is much higher than the PISA results. Several studies in various fields even conformed to the findings that females' level of anxiety is significantly higher than males, and sources of anxiety were even identified in their respective investigations.

Table 3: Gender Disparities in Anxiety, Self-Concept and Self-Efficacy in Math

Variables	Gender	Agree / Strongly Agree *(observed)*	z-value	p-value	Interpretation
Math Anxiety	Female	73.33%	3.3409	0.0008	Significant
	Male	52.50%			
Math Self-Concept	Female	40.83%	1.0399	0.2983	Not Significant
	Male	47.50%			
Math Self-Efficacy	Female	54.17% *	3.9588	0.0001	Significant
	Male	78.33% *			

* Percentage with response of confident and very confident

A study of Seeman (1997, as cited in Hosseinia & Khazal, 2013) disclosed that biological factors affect the anxiety of female. The author who based her conclusion on the examination of the female hormones, said that "the cyclical fluctuations of estrogens and progesterone increase the reaction to anxiety, which gives vulnerability to anxiety" [25].

Psychological factors also affect the anxiety of females according to sources. Psychologist Damour according to Jensen (2019) believed that females are more likely to collapse in on themselves, while males are more expected to act out when distressed [26]. Yousefi and Bahrami said that females have more metacognitive beliefs that worry cannot be controlled and therefore must be avoided [27]. As regard to emotional recognition, Steingard found out that females mature faster than males, thus, their sensitivity make them more susceptible to anxiety [28]. On the other hand, Hosseinia and Khazal in their investigations concluded that the individual's anxiety is the result of both biological and psychological factors and their interactions [25].

Several researches also showed that social factors played important roles in the development of individual's anxiety. Early studies according to Katherine disclosed that many young people normally feel pressure to be perfect in all domains, including schoolwork [29]. According to an expert on females' development, Simmons, perception set even more pressure on females [30]. Syeda in her study found out that the way females rationalize and analyze outcomes of daily life events raise the anxiety risk of females and even parental stress is found contributory to anxiety [31]. On the other hand, Lewinsohn et al. (1998, as cited in Hosseinia & Khazal, 2013) believed that females' susceptibility to anxiety is related to genetic rather than purely based on social factors [25].

Figures in Table 3 also present that significant gender difference was likewise recorded in math self-efficacy of females (54.17%) and males (78.33%) with z = 3.9588 and p = 0.0001. To scrutinize further the difference, the proportions of samples who reported self-efficacy were compared to the PISA findings. Data disclosed that for the mixed gender group, 71.06% of Gen Y and 72.18% of Gen Z demonstrated self-efficacy in 2003 and 2012, respectively. These figures showed wide discrepancy in the reported proportions of sample females of only 54.17%.

This much lower self-efficacy of sample females may be explained by the concept of the Social Cognitive Learning Theory. According to Bandura, a psychologist and author of the said theory, people undermine their self-efficacy if they experience failures, especially if failures occur before efficacy is strongly established; they observe others' failures despite high efforts; they receive discouragement from others; and they rely on their own emotional and physiological states [32].

In his Social Cognitive Learning Theory, he believed that the perceived self-efficacy to exercise control over possible threats plays a central role in the stimulation of anxiety. Bandura said that those who believe they cannot handle unreceptive actions that might happen experience high levels of stimulation of anxiety [33]. This theory of Bandura further states that learning happens in a social context with a dynamic and shared interaction of the person, the behaviour and the environment [34].

Lastly, data in Table 3 indicates that only in math self-concept (z = 1.0399 and p = 0.2983) that the females (40.83%) proportion equates the males (47.50%). It may also be recalled that in Table 1 and Table 2, figures showed that only in math self-concept that no significant difference in the observed and hypothesized

proportions are observed for both females (observed proportion = 40.83%; hypothesized proportion = 48.36%) and males (observed proportion = 47.50%; hypothesized proportion = 48.36%).

As cited in the literature, the development of self-concept may be explained by the Self-Concept Theory. Rogers, a humanistic psychologist and author of the said theory, found out that people who lived in conditional positive outlook believe worthy only if they match with the situation; while people who lived in unconditional positive outlook have the chance to fully actualize themselves [35]. Rogers, in his theory, concluded that for people to grow, they need an environment that will give them acceptance, empathy and genuineness [35].

Conclusions:

The gender disparities of the sample Gen Z Filipino learners were evident in math anxiety and math self-efficacy. This happened because of the high levels of anxiety and low levels of self-efficacy displayed by females. This observation is in conformity with the results of several studies and literature mentioned earlier. Though the sample students of this research belong to the generation who are tagged to be the most technologically literate and socially empowered age group of learners and they even engage in a learning environment that significantly changed, yet the gender gaps remained stable.

Gender differences may be persistent in math due to the stereotyped notion in the society that math is a male-dominated field, and that female remain less likely to enrol in math-related fields. With this belief, females tend to have higher anxiety and lower confidence in their own math ability as compared to males. Data analysis along with the cited studies, provide insights that the biological, psychological and social factors have vital roles in the development not only of ones concept and efficacy but also of anxiety in math. As the theories said, learning happens with a dynamic and shared interaction of the person, the behaviour, and the environment where people can feel the sense of acceptance, empathy and genuineness. To be able to reduce the gender gap in math, it may require therefore, the concerted efforts of the influential actors in the learners' lives, namely their peers, parents and teachers to help counter gendered stereotypes, collaborate on gender equity and create interventions to build female confidence not only in math but also in other academic fields.

Recommendations:

From the conclusions drawn, this study offers the following recommendations to help reduce the gender disparities in learning math. Students, especially females, should learn to develop their full potentials in math, believe in their own capabilities and focus in achieving their goals. Parents should constantly support their children by creating constructive learning environment at home and consistently give unconditional guidance without giving pressure or high expectations from their children in their course of studies.

Teachers should help students develop their self-concept and self-efficacy and reduce students' anxiety by encouraging them to look upon mistakes and setbacks as learning opportunities in math. School administrators should establish strategies to promote positive learning engagement in school and provide scholarly surroundings that will benefit both genders equally.

Policy makers in education should provide directions not just in the process of transmitting subject knowledge to learners but even in creating policies that will foster a productive culture of learning free of gender gap in all academic areas. Members of the society should have collaborated efforts to narrow down the gender gap by changing the stereotype notions of what males and females can and cannot do. Future researchers should conduct further investigations on the gender gaps of learners employing more academic and non-academic variables and also consider other areas in STEM such as the fields of science, technology and engineering which are traditionally believed as male-dominated fields.

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