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Educators' Beliefs on the Gender Difference in Mathematics Performance of their Students

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Authors' contributions

This work was carried out in collaboration among all authors. Author SG designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript, managed the analyses of the study, and managed the literature searches. Authors KPS, NN, and MST were involved in the data collection from the participants. All authors read and approved the final manuscript.

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ABSTRACT

Boys outperformed girls in mathematics test scores as per the recently conducted PISA-D test in Bhutan. Further, as of 2017 from a total of 28,070 STEM-related jobs, 34.3% are female and 64.7% are male. Since educators' teaching practices are associated with their beliefs, this study aims to investigate some of the specific beliefs held by mathematics educators on the gender difference in the mathematics performance of their students. It employed an explanatory sequential mix-method design. Three districts of Bhutan namely Tashigang, Samdrup Jongkhar, and Samtse were covered, from July 2019 to July 2020. From three districts, a sample of 33 mathematics teachers was selected from 18 schools (6 primary schools, 6 middle secondary schools, and 6 higher secondary schools) and 3 colleges. To investigate educators' beliefs a semi-structured survey questionnaire which is the adaptation of Tiedemann [1] was employed. This was followed by interviewing 8 participants from 33 participants. Some of the specific beliefs held by mathematic educators are that educators believe that both the genders can perform equally well in mathematics, average achieving female students are more likely to deteriorate in the subsequent year and average achieving male students endures more in solving difficult questions than their counterparts. Also, 66.7 % of the participants agreed to the gender difference in mathematics

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performance being prominent in higher secondary schools when compared to other types of schools and colleges. Educators believe that male students can perform better in mathematics than female students.

Keywords: Educator; beliefs; gender difference; performance; achiever; mixed-method.

ABBREVIATIONS

Beliefs: It is a mental conviction held by educators consciously or unconsciously that may or may not be true. Here it could be a conviction held by educators about their students' mathematics performance in class or scores in the examinations. Beliefs are not necessarily visible to the outside world but would guide or influence one's own action.
Gender difference: Difference between male and female students in terms of their academic performances in class or scores in examinations.
Educators: Mathematics teachers of schools and mathematics lecturers of the colleges.
Educators' positive and negative beliefs: In the context of this study, the belief can be just categorically classified into positive and negative beliefs but cannot be measured quantitatively. A positive belief is one when the educators have a good notion or good expectation about a particular student concerning the student's academic performance. A negative belief is one when the educators do not have a good notion or good expectation about a particular student concerning the student's academic performance. Therefore, while analyzing the data from the survey questionnaire if the educators' beliefs are congruent with positive statements of the questionnaire, then educators would be said to have positive beliefs otherwise negative beliefs. For instance, if the educators feel that boys should perform better than girls, boys more content with their performance than girls, additional efforts from students and educators' encouragement benefits only boys, and mathematics to be a difficult subject for girls or girls to deteriorate their performance in the next subsequent years. All these forms of beliefs were considered as positive beliefs towards males and negative beliefs towards female students.
BCSEA: Bhutan Council for School Examinations and Assessment
MoE: Ministry of Education
RCSC: Royal Civil Service Commission
PISA-D: Programme for International Student Assessment for Development
STEM: Science Technology Engineering and Mathematics
N: Number of students
SD: Standard deviation
SPSS: Statistical Package for the Social Sciences

1. INTRODUCTION

1.1 Background

In Bhutan, the modern educational system was introduced in the 1960s. Ever since then the number of schools, teachers, and students has increased with the pace of economic development and population. To accommodate this change, many schools and colleges were established. There are different categories or levels of schools such as primary schools, lower secondary schools, middle secondary schools, and higher secondary schools. Within a span of six decades 11 schools have increased to 1132 schools by 2020 [2]. This tremendous achievement in education is because of the efforts and hardships put in by different stakeholders of the kingdom, one among which is the educators.

Bhutan in recent years is seeing some progress in the area of research with tertiary institutions contributing to it, in major ways. Amongst this, many are educational studies being done to understand the influence of certain characteristics of teachers on students. It may be debatable to single out one most influential characteristic. Some of the possible influencing characteristics are qualification, experience level [3], academic ability, and teaching certification [4]. There are many studies done to better understand these characteristics of educators concerning their students. However, not many studies are done to identify educators' beliefs concerning gender differences in students' academic achievement in mathematics.

A lot of educationists with constructivist ideals would argue that students' learning cannot simply be summed up or be measured with students' academic achievement alone. According to Bos and Schwippert [5], the debate over academic achievement is mainly in its measurability (as cited in Ballafkih & Middelkoop, 2003). Some also argue on student achievement not being a wholesome measure to assess student learning. Yet internationally and nationally, in education, academic achievement is still a standard and widely accepted measure of student learning. Since this study investigates the variation of educators' beliefs towards different achiever levels, thus it is worthwhile to classify students into three achiever levels based on the level of academic achievement of the students. Those are high achievers, average achievers, and low achievers.

In Bhutan, there are not many studies done on teachers' beliefs towards two genders in relation to students' academic achievement. However, from the empirical standpoint of the researcher as a practicing educator suggest that there is still a notion in the population that male students can perform better in mathematics than female students. Further, Gurung [6] also reports that there is a statistically significant difference in academic achievement between the two genders where boys outperform girls in mathematics. The study focused simply on the gender difference in mathematics achievement while this study brings in another important aspect to the study which is the teachers' beliefs. Therefore, this study investigates some of the specific beliefs held by educators on the academic achievement of male and female students and identifies the category of schools that has prominent differences in academic achievement between the genders in mathematics.

1.2 Problem Statement

Ideally, both genders should perform equally in mathematics. However, gender differences exist in mathematics. In particular, the differences are distinctly visible in mathematics test scores. From the global context, in 38 member countries of the Organization for Economic Co-operation and Development, boys outperformed girls in mathematics [7]. Similarly, in Bhutan, boys outperformed girls in mathematics test scores as per the recently conducted PISA-D test [8]. The extent of underperformance by girl students is evident in the nationally representative data of BCSEA [9] of higher secondary level indicating mathematics mean scores of 48.12 and 51.02 for girls and boys respectively. At the middle secondary level, the mathematics mean scores are 55.97 for girls, and 57.82 for boys, where the gap is lesser compared to the higher secondary level. But in subjects like English, girls are performing better with mean scores of 54.65 and 52.41 respectively for girls and boys [9].

Mathematics is the core of many technical courses at a tertiary level. This problem merits serious consideration, by appropriate stakeholders, as it may navigate into the future to make graduates less employable. The underperformance by girls in mathematics should be treated as a grave concern to the propagation of education. The gravity of which is being emphasized in the European Commission Report (2015) which asserts that the underperformance of girls in mathematics could be a possible cause for the underrepresentation of girls in high paying and STEM-related jobs, gender-based segregation in the labor market, and gender pay gaps (as cited in Contini et al, 2016). This issue of the gender gap is even more exuberating in the context of Bhutan. That is a representation of women in STEM-related professions such as in the field of architectural and engineering services, medical services, information technology, etc., which is called a Technical Services in Bhutan is underrepresented, with women representation of almost half the men, that is 34.3% female and 64.7% male of total 28,070 [10].

This study may not directly address the issue of gender difference in mathematics performance. But would certainly make the educators and some rightful stakeholders aware of the prevalence of such kind issue in the education system.

1.3 Research Questions

1. What specific beliefs do the educators hold on the gender difference in the mathematics performance of their students?
2. What is the variation in educators' beliefs towards students of different achiever levels?
3. What level of schools or institutions do the educators believe to have prominent gender differences in mathematics performance?

2. LITERATURE REVIEW

Different literature has differing views on the gender gap in mathematics. According to Muthukrishna (2010) as cited by Ajai and Imoko [11] posits that boys perform better than girls in mathematics and more so, boys outperform girls in achieving higher scores than girls on a standardized test. On the contrary, some studies revealed that the gender gap in mathematics is now diminishing [12]. In a developed country like the United States of America, it was found out that the gap was narrowing while in Australia it was reducing and shifting [13].

The concept of beliefs is most often used yet it has no definitive definition. However, in the context of this study, it is more appropriate to use the definition of Sigel (1985) who define beliefs as a mental construction of experience that is often condensed into concepts that are held to be true and would guide the behavior of the individuals (as cited by Ghosh [14].

There is a need to study the educators' beliefs on gender differences in mathematics because the teachers are an important part of the school and their attitude being guided by their beliefs, influences the students' beliefs [14]. Teachers' beliefs play a significant role as it visibly influences their teaching practices in classes. There are studies done on studying teachers' beliefs of boys' and girls' mathematics abilities and how their beliefs influence in narrowing or widening of the gender gap in mathematics. According to the study done at the elementary school level by Fennema, Peterson, Carpenter, and Lubinski [15] points out that teachers believe boys as the best maths students and attribute their success to their abilities while girls' success is to effort. The study done at the middle school level found out that teachers believe boys have more talent and girls compensate the same by hard work [16]. At the high school level, Fennema, Carpenter, Jacobs, Franke, and Levi [17] speculates that the teacher treats and encourages boys more than the girls. In the same line, Jungwirth [18] explains that teachers believe that girls' mathematics learning depends on rote learning, handwork, and perseverance which are in contrast to boys' learning style such as an innate talent, flexibility, and risk-taking(as cited by Ajai and Imoko [11].

There is an intricate relationship between teachers' beliefs and their classroom practice (Ballafkih & Middelkoop, 2003). Despite this intricacy, it is still reasonable to believe that teachers' beliefs about students' academic achievement influence students' academic achievement through their role as a teacher, their attitude, and their opinion [19]. According to Peterson, Fennema, & Carpenter(1989) in their study found out that there is a strong relationship between the beliefs of the mathematics teachers and students' achievement in mathematics. Some scholars argue that the student's achievement improves when the teacher has particular characteristics or beliefs [4].

Moskofoglou & Lekka (2014) suggests a stereotypical belief by the teachers and their beliefs influence the students' perception and expectation of their mathematical abilities [20]. Further, teachers and parents being part of the social environment to the student can also be attributed to boys and girls liking or disliking mathematics [21]. Such kind of teachers' perception could also be contributing to what is called a "self-fulfilling prophecy" [22] where students become self-conscious about their inability to cope-up in mathematics and decide not to put in the effort. However, these female students attribute failure in mathematics to themselves by blaming their own inability (Moskofoglou & Lekka, 2014). The long-term influence of teachers' perception on the girls is that female proves to be less interested than males in pursuing sciences and mathematics-related career [23].

Firstly, while many pieces of literature are available on teachers' beliefs on the gender differences at the elementary or middle school level, there are none in the context of Bhutan. Secondly, although some of the literature points out the fact that gender differences expand with the progression of students from elementary through middle school level to the high school level, ironically, there is no literature at the high school level where the gender differences are more and intense. So this paper aims to fill up that gap. While filling up that gap it will extend the study not just by studying teachers' beliefs at the high school level but will also consolidate literature at the elementary school level and middle school level and will also attempt to make a little beginning at the college level.

3. METHODOLOGY

3.1 Research Design

This study employed an explanatory sequential mixed-method design [24]. The quantitative

aspects of the design were considered through the administration of semi-structured survey questionnaires followed by a qualitative approach that is through semi-structured interviews. It enables the researcher to firstly quantitatively analyze the data and then accordingly obtain richer, elaborate, and more descriptive data through interviews. Since the subject of the study is human beliefs it is difficult to quantitatively measure, thus the mixed-method design was appropriate for this study.

3.2 Data Collection Procedure

To collect the data 'Teachers Survey Questionnaires' of Tiedemann [1] which was used to investigate elementary teachers' gender-related beliefs was adapted to investigate primary, middle secondary, higher secondary, and college educators' beliefs. Tiedemann's questionnaire was adapted as the context of Tiedemann's study was similar to this study. Tiedemann's questionnaire was adapted by excluding items related to the mathematical abilities of their students. The purpose of the main survey questionnaires was to investigate educators' beliefs of girls' and boys' mathematics performance of their students. The same questionnaire has also enabled the researcher to identify the schools or institutions where the gender differences are prominent. While the survey questionnaires were administered to all the participants, the participants for the interview were decided only after the analysis of survey questionnaires.

3.3 Instruments

The survey instrument consisted of two sections. The first section intended to collect the demographic details of the participants while the other section was intended to collect the specific beliefs held by educators about the mathematics performance of their students. The second section had 8 items in the form of statements each indicating either a positive or negative belief related to a student's performance. The questionnaire was with dichotomous questions with true or false responses. The other instrument was a semi-structured interview. While the survey instrument was the adaption of Tiedemann's questionnaire, the questions for the interview were validated by an experienced researcher.

3.4 Research Sites and Participants

This study covered two districts namely Tashigang and Samdrup Jongkhar from eastern Bhutan and one district namely Samtse from southern Bhutan. There were no specific reasons for the selection of these districts other than the convenience of proximity to the researcher. From these 3 districts, the researchers narrowed down schools to 18 schools and 3 colleges. 18 schools comprised of 6 primary schools, 6 middle secondary schools, and 6 higher secondary schools. From each of these schools, 2 mathematics teachers were selected as the participants. Likewise, two university mathematics teachers each were selected from the three colleges which made up a total of 42 participants. However, after the collection of the survey questionnaire and screening them, only 33 participants made up the sample size. Each of the participants was required to identify 6 students (3 male and 3 female) against whom their specific beliefs were investigated. The 6 students would comprise of 2 high achievers (HA), 2 average achievers (AA), and 2 low achievers (LA), 1 male and 1 female from each achiever level. The categorization into achiever levels was done as per students' academic scores. For the interview, 8 participants were randomly selected from the 33 participants to gain an in-depth understanding of the information provided during the survey.

3.5 Data Analysis Procedure

The data obtained through survey questionnaires were entered into SPSS. The SPSS was used to run descriptive statistics. The data collected from interviews were qualitatively analyzed. The qualitative analysis technique employed was thematic analysis. Thematic analysis is a method where the data are scrutinized for identifying, analyzing, and reporting themes or patterns [25]. Since the sequence of collection of data is quantitative and then qualitative, the deductive approach of thematic analysis was used to reason out or back up the findings from the survey data. The survey questionnaires were quantitatively analyzed with the frequency table (Table 1).

4. RESULTS AND DISCUSSION

4.1 Differences in Specific Beliefs Held by Educators on the Gender Difference in Mathematics Achievement

To answer the first research question the data from the survey questionnaire were analyzed in

the form of a frequency table (Table 1). Table 1 is the survey findings of 33 participants against their 198 students of three achiever levels (99 male and 99 female). The frequency count was done for each belief indicator. It allows the researcher to compare the beliefs of teachers against male and female students. While the frequency count is part of the descriptive statistics, the elaboration and substantiation of this data were done with the deductive approach of the thematic analysis. Following are the findings from the survey and interviews.

From indicator no. 6, it can be interpreted that the educators believe that mathematics is a more difficult subject for more percentage of female students that is 47 out of 99 female students than 40 out of 99 male students. From the follow-up interview, it was found that the educators attribute this to the notion that the students have of mathematics becoming more and more difficult with the progression of grades, more so, by female students which causes them into showing less interest in mathematics. From indicator no.1, it can be interpreted that the educators believe that more percentage of male students are content with their performance than female students. That is 59 out of 99 male students are more content than 56 out of 99 female students. From the follow-up interview, this is because they believe male students would usually be content with whatever scores they get while girls' less satisfaction is related to their habit of having to compare with others in the class. Likewise, from indicator no.8, it can be interpreted that the educators also believe that more percentage of female students are likely to deteriorate their performance in the subsequent year. That is 26 out of 99 female students to 14 out of 99 male students. From the follow-up interview, it was found that while there may be other factors, it could be due to significant physical changes that the girls had to go through compared to boys with the progression of grades. For instance, unlike boys, all girls would start to have their monthly menstruation from class five or six. Though natural, this physiological change would divert their concentration and may cause certain disruptions in their studies. Also, from indicator no.5, it can be interpreted that the participants believe that male students show more endurance if the maths exercises are considered to be difficult. That is 78 out of 99 male students to 73 out of 99 female students. From the follow-up interview, the educators likely attribute this to the different ways in which the two genders learn. For instance, if the mathematics exercises are difficult to solve the male students would not easily give up but would try solving the exercise by consulting others in the class or would be more forthcoming to ask their teachers while girls easily give up if it is difficult. Further, from indicator no.2, it can be interpreted that the participants believe that there is a difference in performance between the two genders but the difference is minimal. That is female students insignificantly perform better with 89 out of 99 female students to 88 out of 99 male students. This is especially observed in primary classes as it is at this stage that the girls are more focused, punctual, and have a little bit more sense of competition in their studies. However, from indicator no.3, it can be interpreted that the participants believe that an additional effort from students and specific encouragement from teachers will help both genders to perform equally well [26-34].

4.2 Variation of Educators' Beliefs within the Same Achiever Level

Table 2 below indicates educators' positive beliefs towards students of high achiever level (mean = 7.0, SD = 0.81, N = 66), average achiever level (mean = 6.2, SD = 0.91 N = 66) and at a low achiever level (mean = 4.6, SD = 1.46, N = 66).

Table 3 below indicates educators' negative belief at a high achiever level (mean = 1.0, SD = 0.81, N = 66), average achiever level (mean = 1.8, SD = 0.91 N = 66) and at a low achiever level (mean = 3.4, SD = 1.46, N = 66).

4.3 Institutions with Prominent Gender Differences as Believed by Educators

Table 4 below indicates that from 33 participants, 66.7% of the participants believe that gender difference is prominent at the higher secondary school level with boys performing better than girls. The common theme that emerged from the participants was associated more with the personal factors of the students than with school or teaching and learning-related factors. Participants pointed out that it boils down to the individual level. Some of the possible personal factors identified by the participant were differences in cognitive abilities, differences in the ability to self-regulate their learning, biological differences, differences in emotional maturity, and differences in attention span between the two genders. The participants believe that all this may be contributing to the gender difference in mathematics performance.

Table 1. Specific beliefs of educators towards genders concerning their mathematics performance

Beliefs	Levels	Boys		Girls	
	33 boys & 33 girls from each level	True	False	True	False
Content with performance	High	27	6	23	10
	Average	19	14	20	13
	Low	13	20	13	20
Thinks can perform well	High	33	0	33	0
	Average	33	0	33	0
	Low	22	11	23	10
Effort Helps	High	33	0	33	0
	Average	33	0	33	0
	Low	32	1	31	2
Encouragement is useful	High	33	0	33	0
	Average	33	0	33	0
	Low	31	2	31	2
Little endurance	High	20	13	18	15
	Average	27	6	25	8
	Low	31	2	30	3
Math is difficult	High	1	32	3	30
	Average	10	23	14	19
	Low	29	4	30	3
Will improve	High	31	2	32	1
	Average	32	1	32	1
	Low	27	6	28	5
Will deteriorate	High	1	32	6	27
	Average	3	30	8	25
	Low	10	23	12	21

Table 2. Variation of positive belief towards students of different achiever levels

Achiever Levels	Beliefs	N	Mean of frequency of PB	SD
HA	Positive belief(PB)	66	7.0	0.81
AA	Positive belief(PB)	66	6.2	0.91
LA	Positive belief(PB)	66	4.6	1.46

Table 3. Variation of negative belief towards students of different achiever levels

Achiever Levels	Beliefs	N	Mean of frequency of NB	SD
HA	Negative belief(NB)	66	1.0	0.81
AA	Negative belief(NB)	66	1.8	0.91
LA	Negative belief(NB)	66	3.4	1.46

Table 4. Institutions with prominent gender differences as believed by educators

Sl. No.	Institutions	Frequency	Percentage
1	Primary School	4	12.10 %
2	Middle Secondary School	3	9.10 %
3	Higher Secondary School	22	66.7 %
4	Colleges	4	12.10 %
	Total	33	100%

4.4 Discussion

This study reveals some of the differences in the specific beliefs held by educators towards two genders which they themselves are not aware of. Their beliefs one way or other is in favor of male students. Educators believe that on average female students find mathematics more difficult than male students. In particular, average achieving female students find mathematics more difficult than average achieving male students which is consistent with one of the findings of Tiedemann [1]. This study points out that educators believe that on average male students are more content with their performance than female students. Specifically, high achieving male students are more content with their performance than high achieving female students. Educators also believe that on average the female students are more likely to deteriorate in their performance in a subsequent year. In particular, the average female students are more likely than equally achieving male students to deteriorate which is in contradiction to the finding of Tiedemann [1]. Further, educators believe that if mathematics exercise is considered to be difficult, on average the male students show more endurance than female students. Specifically, average male achievers endure more than their equally achieving counterparts. According to Tiedemann [1], educators believe that female students benefitted less than male students from the additional effort, however, this study found that educators believe that both genders benefitted equally from the additional efforts, and both the genders can perform equally well.

This study establishes that there is a variation of educators' beliefs towards different achiever levels. This variation can be attributed to the kind of achiever level of the students. The educators with positive beliefs about students' performance had higher intensity of positive beliefs towards high achievers than low achievers. Also, the educators with negative beliefs about students' performance had a lower intensity of negative beliefs towards higher achievers than low achievers. For instance, if the students are high achievers the educators would believe that these students are more satisfied with their performance; have high endurance in solving difficult exercises; mathematics not a difficult subject for them; and characterize them as hardworking, more punctual, more responsible, and good at logical thinking.

Lastly, higher secondary schools were found to have more gender differences with boys performing better in mathematics which can be attributed to the personal factors of the students.

5. CONCLUSION AND RECOMMENDATIONS

This study concludes that the educators' beliefs are more in favor of male students where they believe male students to be performing better than female students. The variation in educators' beliefs to a certain extent may depend on the achiever level of the students. Also, the mathematics educators believe that higher secondary schools have more differences in mathematics performance between the two genders when compared to primary schools, middle secondary schools, and colleges. Besides identifying some of the beliefs held by the educators, the novelty of this study is in being able to find out that there are variations in educators' beliefs towards different achiever levels. However, since belief itself is quite difficult to define clearly the finding of this study may seem vague especially in the quantitative analysis part, so there is a scope for the use of inferential statistics in the future.

One of the reasons cited by some of the teacher participants in this study for girls being behind boys in mathematics performance in higher secondary school could be because of the personal factors associated only with the woman. The participants said girls by adolescent age reach higher secondary schools during which most of their physiological changes take place. Amongst many, one could be monthly menstruation. Although it is natural, most girls are found to be more distracted or inattentive in the classes during such times. Because it is physically draining and mentally exhausting for girls to attend the class and at the same time to manage menstruations. Therefore, the school administrations may have to consider their attendance or be lenient with their inability to attend class during menstruation time.

CONSENT

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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