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Research Article

EXPLORING STUDENTS' PERCEPTIONS OF MATHEMATICS

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ABSTRACT

This study examines the determinants of perception of mathematics among postgraduate management students, including the influence of fathers, mothers, peers, and teachers. The study was conducted with postgraduate management students in Bangalore, India. The respondents were in the age group 21-28 years, with varied demographic and educational backgrounds.
The results of the study suggest that the influence of peers had the strongest impact on the perception of mathematics. Thus, the perception of mathematics can be maximally enhanced amongst students by leveraging peer group learning. The peer groups and group assignments must be carefully designed so that the students are encouraged to support one another according to their abilities, and to contribute to overall group learning.
The finding that the influence of peer groups has the strongest impact on the perception of mathematics is an original contribution to the literature, as earlier studies had not focused on the impact of peer group influence on students' perception of mathematics. However, the composition of the peer group, and its impact on the perception of mathematics needs to be examined more carefully. In fact, the interaction between the different influence factors is another important aspect that needs to be studied in more detail, including the influence factors studied in the literature. An experimental design would probably be more appropriate for this; however, there may be difficulties in identifying/assessing the long-run impact of these factors. Thus, there is vast scope for further, more detailed study in this area.

Keywords: Perception of mathematics, Postgraduate management students, Peer groups.

INTRODUCTION

Mathematics as a discipline is as old as the human race itself is. In ancient times, the Mesopotamians and the Egyptians (circa 3000 B.C.) introduced the number system, addition, multiplication, division, and fractions. They also introduced the roots of algebra and mensuration (area and volume computation). The Babylonians gave the foundations of algebra: systems of equations in many unknowns and their solutions, quadratic equations, square roots and cube roots, and so on. The Greeks also had many contributions to mathematics and geometry. The most important of ancient Indian contributions to the field of mathematics was the number of 'zero.'
The current uses of mathematics, its complexity, and its specialised branches are quite vast and varied, and it is beyond the scope of this study to list them in full. With the increased complexity of mathematics, however, came increased fear of mathematics.
The fear of numbers is called disparnumerophobia. It afflicts a large segment of the population, all over the world. Such a phobia affects those who suffer from it, hampering them from living normal lives, especially when learning anything related to mathematics. This fear could have originated owing to an unpleasant experience or situation. The impact is seen to be so severe that the body develops a phobia for anything related to that situation, rejecting the fear physically by not processing any information related to it. These phobias may have no clear-cut origin and may pertain to specific numbers or to numbers in general. Some of the examples of this are as follows.
The fear for the number six hundred and sixty-six (hexakosioihexekontahexaphobia) pertains to the fact that it is considered to be the Devil's number, and should be avoided so as to avert ominous consequences. The fear of the number thirteen (triskaidekaphobia) is owing to its association with bad luck. Centuries-old stories exist for this particular phobia, most popular of which is the concept of Friday the 13th that has been immortalised in cinema worldwide. The fear of number four (tetraphobia) is believed in Japan exists because the pronunciation of the word four in Japanese is "shi" synonymous with death. Other phobias include the number eight (octophobia), the number twenty-three (duotriphobia), and the number three (triskaphobia).
Phobias are believed to be a result of combination of external traumatic events and internal predispositions. Many specific phobias can be traced back to a specific triggering event, usually a traumatic experience at an early age. For instance if a student receives harsh punishment for making a mistake in mathematics, the impact will be to create a mental block owing to the pain and humiliation felt by the student at the time of event - subsequently the harmlessness of the numbers is unable to overpower the impact they had on the psyche of the student. Also, the frequent inability of mathematics teachers in schools to relate the discipline to the real world may cause the problem of students' inability to generate and sustain interest, or to overcome the negative phobias associated with the discipline.
A more prevalent form of fear of numerals or quantitative calculations in general is that of mathematics anxiety. It pertains to fear of mathematics as an insoluble conundrum - why some students struggle with numbers and calculations while others do not appear to face similar problems. Mathematics anxiety is expressed through general anxiety, sweaty palms, frustration, sleep trouble, hyperventilation, and even panic, when the individual has to deal with quantitative problems. It can lead to poor performance owing to avoidance of working at the subject. Subsequently the belief that they are not good at the mathematics is reinforced when students avoid studying the subject and doing homework, ultimately resulting in them opting for majors in college that keep them as far away from mathematics as possible (Ashcraft and Faust, 1994).

BACKGROUND OF THE STUDY

Mathematics anxiety has received increased attention in the academic literature in recent years. According to Ashcraft and Kirk (2001), more than 20% of the population suffers from psychological or physiological problems when dealing with quantitative problems, which in turn can affect their performance in educational and professional contexts.
There are several studies addressing societal influences on mathematics anxiety. Jain and Dowson (2009) examined

several factors affecting mathematics anxiety. Beilock et al., (2010) argued that mathematics anxiety among students is often aggravated by social contexts. Devine et al., (2012) classified the factors affecting mathematics anxiety into environmental factors, cognitive factors, and personality factors.

Amongst the environmental factors, the most critical are those related to the teachers, including teachers' attitudes, stereotypes, and teaching style/competence, as these have a direct effect on a student's attitudes, motivations, and learning activities (Ashcraft and Ridley, 2005). Turner et al., (2002) showed that teachers with distant and unsupportive attitudes increase students' avoidance of mathematics. Beilock et al., (2010) suggested that women teachers suffering from mathematics anxiety can transmit their fears implicitly to their girl students, reinforcing stereotypes (i.e. "boys are good at math, girls are good at reading"). Parental influence is also an important factor influencing children's attitudes towards mathematics. Eccles et al., (1990) suggest that parents play a critical role in propagating gender stereotypes in children's self-perceptions, interests, and skill acquisition."

Amongst the cognitive factors, poor mathematical competencies may contribute to mathematics anxiety; however, this may not have as much impact as non-cognitive factors (Suinn and Edwards, 1982). Some cognitive aspects such as good abstract thinking abilities may reduce the incidence of mathematics anxiety. Maloney et al., (2012) suggest that visuo-spatial processing abilities could mediate gender differences in mathematics anxiety.

Amongst the personality factors, self-efficacy beliefs with respect to numerical and arithmetic tasks and related self-regulation skills are key factors in the development of mathematics anxiety (Jain and Dowson, 2009). Other personality factors affecting mathematics anxiety include test anxiety, a generalized fear to fail, negative attitudes towards learning, and low self-efficacy beliefs (Bandalos et al., 1995).

Pantziara and Philippou (2007) studied the antecedants of fear of failure in mathematics, including family conditions, student characteristics, and teacher practices. They asserted that fear of failure was primarily a consequence of social inequalities supported by differences in the father's educational background, also negatively affected by the help students receive during their homework, their mathematical performance, and their self-efficacy. They suggested that, as institutions impact the self-efficacy of the students the most, instructors should play a more proactive role in shaping the self-efficacy of the students. In fact, teachers' practices contribute to different motivational constructs, due to a close interaction between the students' cognitive factors and the teachers' practices. Amongst teachers' characteristics, teachers' sensitivity had the greatest impact on the students' fear of failure, imbibing such practices as discussing multiple solutions of a problem, pushing students to understand, and giving individual help to students.

Ramirez et al., (2013) studied mathematics anxiety among elementary school children, and found a negative relation between mathematics anxiety and mathematics achievement, moderated by working memory. In particular, they found that high working-memory children tend to rely on working-memory-intensive solution strategies, which tend to be disrupted when working memory is affected by mathematics anxiety. In a follow-up study, Ramirez et al., (2016) found that children's mathematics anxiety negatively related to their use of more advanced problem-solving strategies, which in turn related to mathematics achievement, with this latter relation being strongest among children with high working memory capacity. In particular, they found that children with higher cognitive capacity avoid using advanced problem-solving strategies when they are affected by mathematics anxiety, resulting in lower mathematical performance as compared to their lower working-memory peers.

The literature on perception of mathematics and mathematics anxiety among school and college students highlights several important antecedents. However, a potentially-important environmental factor not investigated much in the literature is that of peer group and peer pressure. Peer group may have a positive or a negative influence on children's attitude towards mathematics. For example, if a child's peer group has children who are good at mathematics, they may motivate the child to try harder to overcome their mathematical difficulties. On the other hand, if a child's peer group has children who are affected by mathematics anxiety, the child may also develop mathematics anxiety.

SIGNIFICANCE OF THE STUDY

The current study contributes to the literature by considering the effect of peer group, along with several other factors, on the perception of mathematics.

OBJECTIVES

The objective of the study was to analyse and compare the influence of fathers, the influence of mothers, the influence of peers, and the influence of teachers on the perception of mathematics.

HYPOTHESES

The influence of teachers would be expected to have the most impact on the perception of mathematics, based on the literature. Also, the influence of parents would also be expected to have a major impact on the perception of mathematics, especially in the Indian context with many parents pressurising their children to study engineering. The influence of peers would also be expected to have a significant impact on perception of mathematics, but it is not a priori clear whether this impact would be positive or negative.

METHODOLOGY

The data for the study was collected from a sample of fifty-five postgraduate management students in Bangalore, selected by convenience sampling. The respondents were generally in the age group 21-28 years, with varied demographic and educational backgrounds.

The respondents were classified into three groups: those with negative perception, those with mixed/neutral perception, and those with positive perception. This was subdivided on a nine-point rating scale, as follows. At the extreme negative end, the rating 1.0 represented 'strongly dislike,' for respondents who found mathematics to be very difficult. The rating 1.5 represented 'highly dislike,' and 2.0 represented 'dislike.' In the middle ground, the rating 2.5 represented 'somewhat dislike,' the rating 3.0 represented indifference, i.e. 'neither like nor dislike,' and the rating 3.5 represented 'somewhat like.' On the positive side, the rating 4.0 represented 'like,' and the rating 4.5 represented 'highly like.' At the extreme positive end, the rating 5.0 represented 'strongly like,' for respondents who found it to be very easy.

The primary determinants of perception of mathematics considered were the influence of fathers, the influence of mothers, the influence of peers, and the influence of teachers. The influence factors were measured on a seven-point scale. Correlation and regression analyses were used to study the impact of the influence factors on the perception of mathematics.

Though studies show that girls tend to have higher levels of mathematics anxiety than boys throughout their schooling (Devine et al., 2012), there is no evidence to suggest that this is true in the Indian context. Thus, gender was not considered as a determinant of perception of mathematics in the current study.

RESULTS

The distribution of the respondents' perceptions of mathematics is presented in Table 1 below.

Table 1: Perception of mathematics

Particulars	Freq.	Percentage	Perceptions	Freq.	Percentage
Strongly dislike	07	12.7%	Negative	20	36.4%
Dislike	13	23.6%			
Somewhat dislike	02	3.6%	Neutral/mixed	12	21.8%
Neither like nor dislike	05	9.1%			
Somewhat like	05	9.1%			
Highly like	19	34.5%	Positive	23	41.8%
Strongly like	04	7.3%			

Amongst the respondents, 36.4% had a negative perception of mathematics, 21.8% had neutral/mixed perception, and 41.8% had a positive perception. In particular, 12.7% of the respondents expressed a strong dislike for mathematics, either in the form of fear, or of hatred. At the other extreme, 7.3% of the respondents expressed a love for mathematics.

Another variable of interest was the critical age, at which the perception developed. Positive perceptions were developed at an average age of 12.44 years, with standard deviation 2.83 years; negative perceptions were developed at an average age of 13.15 years, with standard deviation 2.92 years; and mixed perceptions were developed at an average age of 14.00 years, with standard deviation 3.13 years. However, there was found to be no significant difference in the average age across groups ($F = 1.149$, $p = 0.325$).

The descriptive statistics of influence factors on the respondents' perception of mathematics across perceptual groups is presented in Table 2 below.

Table 2: Descriptive statistics of influence factors across perceptual groups

Factors		Negative	Neutral/ mixed	Positive	Overall	F stat	p value
Influence of fathers	Mean	3.400	3.333	3.783	3.54	1.570	0.218
	Std. Dev.	0.754	1.073	0.795	0.857		
Influence of mothers	Mean	3.652	3.550	3.250	3.527	0.976	0.384
	Std. Dev.	0.866	0.887	0.714	0.813		
Influence of peers	Mean	2.650	3.167	3.587	3.155	10.158	0.000
	Std. Dev.	0.690	0.835	0.577	0.787		
Influence of teachers	Mean	2.825	2.875	3.848	3.264	10.671	0.000
	Std. Dev.	0.784	1.003	0.682	0.927		

The distribution patterns of the influence of fathers and of mothers were similar, with a positive influence for 56.4% and 58.2% of the respondents, respectively, and a negative influence for 12.7% of the respondents for both. The negative influences of parents identified by respondents included over-stressing the importance of mathematics; strictness, pressurizing/forcing/coaxing respondents to study; and in some cases punishing the respondents for making mistakes/scoring low marks.

The distribution patterns of the influence of teachers and peers were more towards the extremes, with a positive influence for 45.5% and 38.2% of the respondents, respectively, and a negative influence for 25.5% and 23.6% of respondents, respectively. The negative influences of teachers identified by respondents included incompetence ("didn't know how to teach"; "didn't clarify concepts"); strictness/pressurizing respondents ("killed interest"); lack of special attention; and in some cases scaring and scolding respondents for making mistakes. On the other hand, the positive influences of teachers identified by respondents included patience, helpfulness; inspiring/motivating/encouraging; clarifying concepts, using alternative teaching methods (e.g. connecting with a story); and in some cases the mathematics teacher was the respondent's favorite teacher and the respondent was the mathematics teacher's favorite student. The negative influences of peers identified by respondents included comparative worse performance relative to peers and reinforcing fear; on the other hand, the positive influences of peers identified by respondents included comparative better performance relative to peers and positive competition.

There was no significant difference in the influence of parents across the perceptual groups. However, the influence of teachers was significantly higher for the positive perceptual group than for the neutral and negative perceptual groups, and the influence of peers was significantly higher for the positive and neutral perceptual groups than for the negative perceptual group.

Also, 54.5% of the respondents felt that community could have an impact on perception of mathematics, while only 18.2% of the respondents felt that instruction in mother tongue could have improved their perception of mathematics. In fact, it was suggested by several respondents that culture and environment would have an impact on perception of mathematics. One respondent theorized that "People good at mathematics will have children good at mathematics." On the other hand, not many respondents felt that mother tongue would have an influence, and mathematics was fundamentally logic-based.

The correlations between the perception of mathematics and the influence factors are presented in Table 3 below.

Table 3: Correlation of perceptions with influence factors

Factors	Perception	Influence of fathers	Influence of mothers	Influence of peers
Influence of fathers	0.239			
	(0.039)			
Influence of mothers	0.113	0.802		
	(0.207)	(0.000)		
Influence of peers	0.548	0.298	0.348	
	(0.000)	(0.013)	(0.005)	
Influence of teachers	0.487	0.247	0.168	0.476
	(0.000)	(0.035)	(0.110)	(0.000)

Table 4: Regression of perception on influence factors

Factors	Coeff.	Std. error	Beta	t stat	p value	VIF
(Constant)	-0.227	0.818		-0.277	0.392	
Influence of fathers	0.497	0.295	0.314	1.687	0.049	2.921
Influence of mothers	-0.565	0.313	-0.339	-1.803	0.039	2.980
Influence of peers	0.779	0.225	0.452	3.464	0.001	1.434
Influence of teachers	0.368	0.185	0.252	1.995	0.026	1.345

Dependent variable: Perception of Mathematics; R^2 = 40.7%, DW = 1.880, F stat = 8.583, p-value = 0.000*

The perception of mathematics was found to be significantly positively correlated with the influence of the father, the influence of peers, and the influence of teachers. Also, there was significant positive correlation between the influence factors.

The regression of the perception of mathematics on the influence factors across perceptual groups is presented in Table 4 below.

The regression was found to be statistically significant, explaining 40.7% of the variation in the perception of mathematics. All of the influence factors were found to have a significant impact on the perception of mathematics. The variable with strongest impact was the influence of peers, followed by the influence of the mother, the influence of the father, and the influence of teachers. The influence of the father, the influence of peers, and the influence of teachers all had a positive impact on the perception of mathematics, while the influence of the mother had a negative impact on the perception of mathematics.

DISCUSSION

The results of the study suggest that the influence of peers had the strongest impact on the perception of mathematics. Thus, the perception of mathematics can be maximally enhanced amongst students by leveraging peer group learning. The peer groups and group assignments must be carefully designed so that the students are encouraged to support one another according to their abilities, and to contribute to overall group learning.

Another interesting finding was that, though the influence of fathers and mothers were both statistically significant, fathers tended to have a positive impact, while mothers tended to have a negative impact; however, the combined impact was not statistically significant. This finding is contrary to that established in the literature, with several studies showing that parents play a crucial role in the development of mathematics anxiety (e.g. Eccles et al., 1990), though the negative impact of mothers parallels the findings of Beilock et al., (2010) that women teachers suffering from mathematics anxiety can transmit their fears implicitly to their girl students. Perhaps the inclusion of gender as a variable could have enabled a more careful examination of the interaction between gender and parental influence.

Of the factors considered, the impact of the influence of teachers on the students' perception of mathematics was the least strongest, though quite statistically significant. This in fact inverts the established hierarchy of factors, in which teachers' influence is the most critical factor (e.g. Turner et al., 2002; Ashcraft and Ridley, 2005; Beilock et al., 2010). In particular, teachers should undertake a more motivational and supportive role in mathematics education, encouraging learning through closer interaction with students and helping students with their learning difficulties. Further, mathematics education should be made more application-oriented, and the pedagogy should be redesigned to accommodate individual as well as peer group learning.

There are several limitations inherent in the current study. The sample size was very small, and the sampling method was non-probabilistic, so the results of the study may not be generalizable. Also, the background of the respondents was not controlled for; studies show that the father's educational background in particular has an impact on mathematics anxiety (e.g. Pantziara and Philippou, 2007). Further, several other determinant factors in the literature were not considered in the current study.

The finding that the influence of peer groups has the strongest impact on the perception of mathematics is an original contribution to the literature, as earlier studies had not focused on the impact of peer group influence on students' perception of mathematics. However, the composition of the peer group, and its impact on the perception of mathematics needs to be examined more carefully. In fact, the interaction between the different influence factors is another important aspect that needs to be studied in more detail, including the influence factors studied in the literature. An experimental design would probably be more appropriate for this; however, there may be difficulties in identifying/assessing the long-run impact of these factors. Thus, there is vast scope for further, more detailed study in this area.

CONCLUSION

The results of the study highlight the importance of peer group learning on the perception of mathematics. Peer groups provide a socio-psychological context for the formation of perceptions towards mathematics and are effective media for transmitting mathematics learning. Mathematics education should increasingly leverage peer group learning to spread positive perceptions among students, as well as to improve student understanding. Without positive perceptions, mathematics remains relatively inaccessible to a large majority of students.

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AUTHORS' CONTRIBUTIONS

The first author was involved in the design of the study and analysis of the data. The second author was responsible for data collection and literature review. Both authors were jointly involved in writing the paper.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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