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Original Article

Educational Equity in Numbers: Exploring Demographic and Economic Influences on School Numeracy for Students of ages 8-13 in Bengaluru, India

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Abstract *- Numeracy skills are an especially prevalent issue in students of a low-income family background. This research took place in a school for students of a lower Socio-Economic Status(SES) in Bangalore, India. Students of grades 4-7 were surveyed on two different factors: demographic background and mathematical ability. For the demographic aspect, students were asked questions about their daily life and family. For numeracy, the government-assigned textbook was used as a basis for the questions. Due to the system of school in India, the survey was done at the beginning of the new academic year. Therefore, the students were assessed based on the material taught in their previous grade. Through this research, the aim was to see where the issue is in the numeracy of students in a lower SES. The data was collected through a google form with a translator, who was asking all the questions in Kannada. The students were not able to do simple mathematics, and their numeracy levels were very low. They were averaging around 4-5 on a 30-question test. This data shows that there is a need for an intervention because of the results obtained from the research.*

Keywords *- Academic performance, India, Mathematics, Numeracy, Socio-economic status.*

1. Introduction

Mathematics has always been considered a fundamental subject in a child's education journey. [1] Being proficient in mathematics allows one to analyze data, make meaningful decisions, and solve real-world problems effectively. In addition to this, the sudden surge in Artificial Intelligence (AI) has created a lot more jobs, such as AI product manager, AI research scientist and Computer vision engineer, most of which require mathematical skills. The ideas behind thinking machines and the possibility of mimicking human behavior are all done with the help of mathematical concepts and models. [2]

Numeracy refers to the ability to comprehend and use numbers. This encompasses a vast range of topics, from simple addition to algebra. Studies have shown that this is highly affected by a person's socio-economic status. [3] Socio-economic status or SES is a measure based upon two factors. The first of these is economic status, which judges one's personal and family income and wealth in comparison to others in society when placed in a group. The other aspect is an individual's social status, based upon factors such as the level of their occupation and past education [4], which is used to evaluate an individual's occupation prestige' in the eyes of the general public. Chen et al. (2018), in their study, have shown that SES is a critical indicator of factors like parental education, income and occupation significantly influencing the academic achievement of their children. [5] If not done in early childhood, these learning gaps increase, leading to a "cascade of mathematics failure". As students go to higher grades, the gap between students of lower SES and those of higher SES increases, and they fall behind. Another common reason for this is due to a lack of attention and concentration of students of a lower SES. [5] This may be caused by other demands or tasks that might not be attended to. As a result, knowledge is not gained in the classroom. Data shows that children from lower-SES households are about 1.5 times as likely as those from high-SES households to display learning-related behavior problems. [6] Learning motivation is also significantly lacking in those of lower SES, as Chen et al. (2018) concluded through research. [5]

The present study focuses primarily on numeracy skills in younger students. Children of a government-funded school

have been assessed on their mathematical ability. A short test was created to see if students of a lower SES possess proficiency at numeracy and the reasons for having the proficiency or not having it. Many studies have shown that children of a lower SES lack when it comes to mathematics. [7] It states that the 'education of the mother of a child impacts how well the child does'.

This is due to the mother being the primary caretaker of the child. [5] Another relationship is that the children of lower SES have lower motivation and, therefore, learning ability. This is evident, especially in English and Language subjects. [8] This study aims at understanding the current gaps in numeracy skills.

A 30-question survey was created for grades 4-7. This consisted of demographic questions relating to their family members, number of friends, family occupations, etc., and a mathematical ability test. Since the students had just graduated into the grade that they were in, the government-assigned textbook from their previous grade was used to assess their competence.

The data from the present study showed that, albeit slight differences on the basis of friends, family members, etc., all students scored extremely poorly. A constant trend was that the more friends one has, the better their score. Family members also have an effect on the younger children but not on the older ones.

2. Literature Review

Socioeconomic status is an extremely important factor when it comes to numeracy for a number of reasons. Jordan & Levine (2009) have shown that a lower SES and the associated lack of resources and influences often negatively affect a student's level of mathematics, which often results in a cascade of failures as the children grow up and realize the importance of mathematics in their lives. [6] In their study, Kamal et al. (2017) have illustrated the importance of a mother's education on a child's educational outcome among students belonging to lower SES; the study further adds that educational outcomes are often directly proportionate to parental involvement in children's education.

[9] Overall, we find that students belonging to lower SES backgrounds often fall significantly behind their privileged peers, either due to a lack of parental resources or because they are often required to take up jobs to supplement their family incomes, which results in them substituting their time away from academic engagements, which ultimately results in them underperforming in class. Also, a general lack of awareness among parents regarding the importance of education as a whole and the nature of prospects it can potentially offer to their students in the long run significantly affects the motivation and participation of children from disadvantaged backgrounds.

3. Materials and Methodology

3.1. Research Aim

This research aims to analyze the mathematical ability of children of a lower SES based on demographic factors, which are mentioned below.

3.2. Data Collection Method

A survey was created, through which data was collected and analyzed. About 3-4 students took the survey at the same time, away from each other, so that they did not cheat. The survey was presented to grades four, five, six and seven. This consisted of demographic questions relating to their family members, number of friends, family occupations, etc. and also included a mathematical ability test. Since the students had just graduated into the grade that they were in, the government-assigned textbook from their previous grade was used to assess them fairly. The teachers of the school obtained consent, and the students' personal data will not be shared with anyone.

Table 1. This table lists the various demographic aspects covered in the survey and the trends found

Theme	Discussion
Which gender performed better at numeracy?	There was no particular gender that performed better.
Impact of eating breakfast on numeracy	This has always shown to be a positive correlation, even seen in this survey.
Impact of number of friends on numeracy	The more friends a student had, the better they performed
Impact of number of family members on numeracy	It varied from grade to grade, but the theme was that in the lower grades, it is a direct proportion, whereas it is indirect for the older grades.
Impact of external tutoring on numeracy	The sample size for this in most of the grades is rather unrepresentative; therefore, a certain conclusion cannot be drawn.

3.3. Survey Description

The survey consisted of two parts - a demographic section and a mathematical ability test. The questions in the demographic section are the ones mentioned above in Table 1, along with name, age and what they want to be when they grow up. For mathematical ability, the questions presented started with addition, subtraction, multiplication and division,

followed by word problems, shapes, time and money. The level of difficulty varied according to the grade of each respondent; the survey was administered using Google Forms.

Table 2. Gender and Grade-wise composition of Respondents/students

	Male	Female
Grade 4	5	8
Grade 5	12	15
Grade 6	13	16
Grade 7	12	15
Overall	42	54

3.4. Data Analysis

The data was analyzed on many bases, including relating the demographic topics above to the student's mathematical ability. The student's dream job was also analyzed with regard to their gender. T-test was performed on the effect of family size, the effect of number of friends, the effect of eating breakfast in the morning, and the effect of gender. ANOVA was performed to determine the effect of grade on total correct answers.

3.5. Ethics

Consent was taken by the teachers of the school and the student's personal data will not be shared with anyone.

4. Results and Discussion

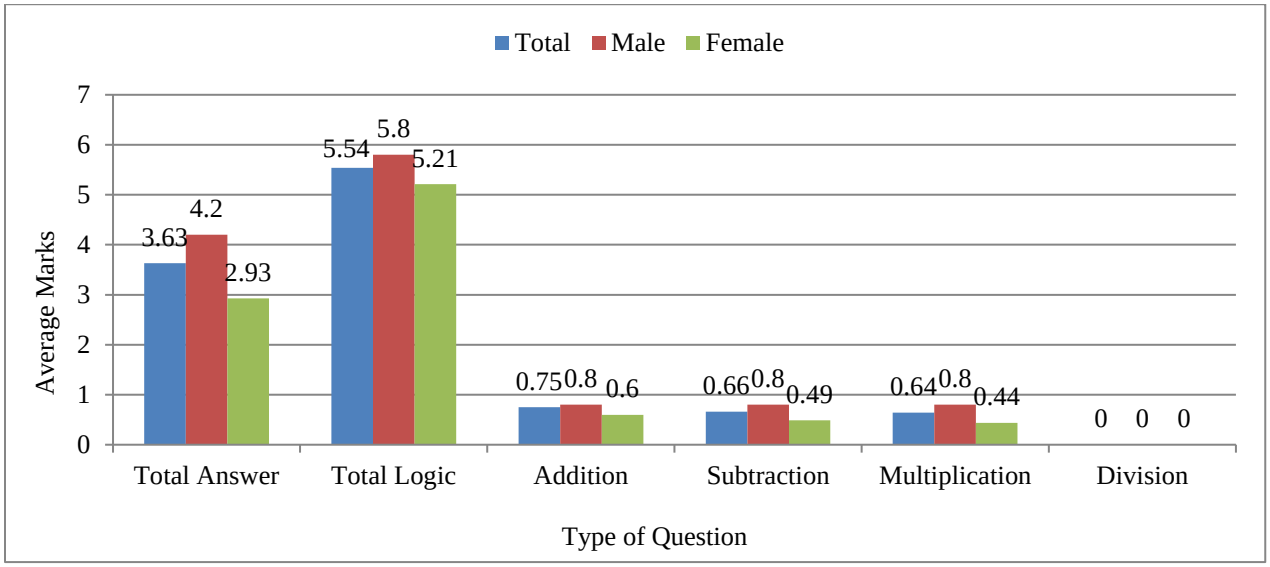


Fig. 1 Number of questions answered correctly by students of Grade 5 based on gender

Note: The questions asked were in different categories, such as total answers, total logic, addition, and subtraction. (N = 13; Male = 5, Female = 8)

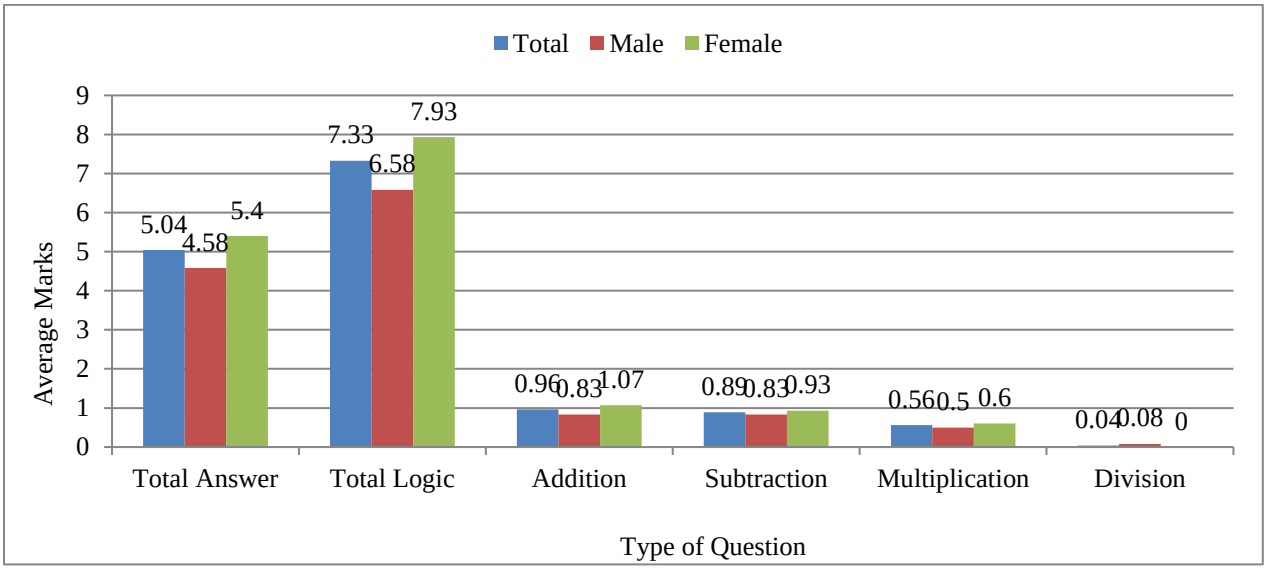


Fig. 2 Number of questions answered correctly by students of Grade 5 based on gender

Note: These are scores across multiple categories such as total answers, total logic, addition, subtraction, etc.

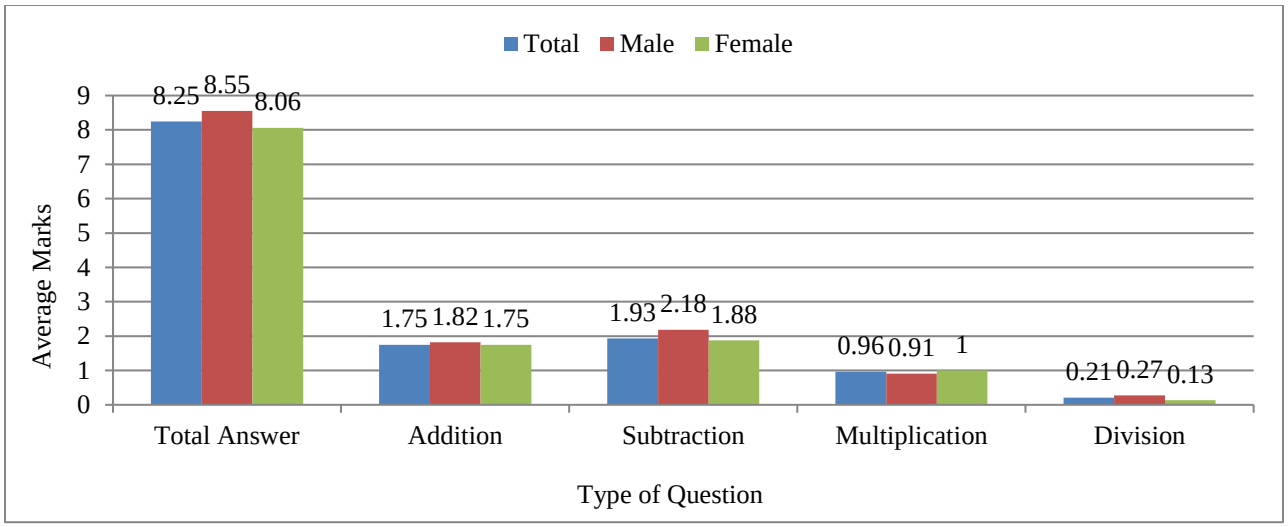


Fig. 3 Number of questions answered correctly by students in Grade 6 based on gender

Note: These are in multiple categories, such as total answers, addition, subtraction, etc., and they also show the difference between the number of questions boys and girls got correct on average.

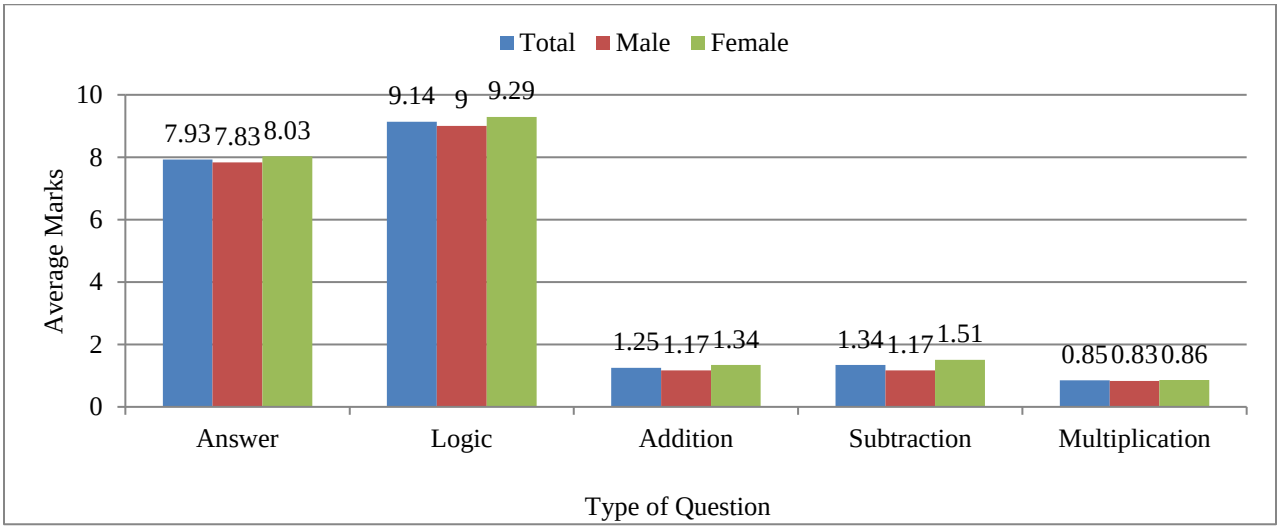


Fig. 4 The number of questions students in grade 7 answered correctly based on gender

Note: These are in multiple categories, such as total answers, addition, subtraction, etc. and also show the difference between the number of questions boys and girls got correct on average.

As illustrated in Figure 1, males in grade 4 generally grasp the concepts better than females. There is a smaller male population in the class. The average score in total answers is greater for male (4.20) than female students (2.93), as shown in Figure 1. However, the gap in average scores in total logic is significantly less for male (5.8) and female (5.21) students. For addition, subtraction and multiplication tests, males again scored better than females, as shown in Figure 1. These parameters were measured out of 2 questions. Division, on the other hand, could not be answered by any of the students. Because of the small data set, this may not be conclusive evidence. From these findings, it can be inferred that these children have not been taught division despite it being in their syllabus since nobody could answer the division question. In Figure 1, it can be seen that the overall scores are 3.63 out of 17, which reflects the inadequate amount of teaching and learning. As reported by ACER in 2018, boys in Grade 4 in India have an average score of 5.38 higher than girls. This matches the trend that can be seen in Figure 1. [10]

Figure 2 shows that females in grade 5 generally have a higher average score in overall concepts as opposed to males. There is a smaller male population in this grade as opposed to females. The average overall scores show a significantly large gap, where female students (5.4) have greater scores than male students (4.58). It should be noted, however, that these scores are out of a total of 27 marks. In total logic, the same difference is evident, where female (7.93) averages are larger than that of male (6.58). In addition, in subtraction and multiplication, a less evident gap can be viewed, where

females still have the larger average. These parameters were measured out of 2 total marks. Division, however, had 1 male answer correctly, therefore being the only topic where the male average was higher. However, there are still barely any students that could answer the division question. As a previous study by Rahmawati and Romaya (2023) has shown, the methods of thinking for boys and girls in grade 5 vary. Male students tend to try applying and then constantly recheck, whereas female students are able to understand the question fluently and link facts to solve it. [11] Therefore, the female students probably did better.

Figure 3 shows that males in Grade 6 have higher averages than females in every topic assessed. It should be noted, however, that the gap is significantly small, often being less than half a point. In overall scores, males (8.55) only barely beat females (8.06) in marks. Females (1.00), however, did do better than males (0.91) in multiplication by a very small margin again. Adu and Duku (2021) in their study have illustrated that there is no significant gender difference in mathematics for students enrolled in Grade 6. [12]

It can be seen from Figure 4 that grade 7 females have a higher average than males in all topics. Similar to grade 6, the margin between males and females is relatively small. This finding is in contrast to articles like Cheung et al. (1989), which argue that males in grade 7 perform better than females when it comes to mathematics; however, this study was done in Hong Kong, and the SES may differ from that in our current work. [13]

From the above four graphs, it can be seen that there is a gender gap when it comes to the younger grades, but that gap slowly started to decrease as they went to higher grades. Even other research papers have shown that this gender gap becomes statistically insignificant as they grow older.[12] Other than that, one very big observation is that none of the children were able to divide. This may be because division is a harder concept.

Table 3. Effect of number of family members on mathematical performance

	Answers		Logic	
No. of family members	>4	<=4	>4	<=4
Grade 4	4.17	3.86	5.43	6.67
Grade 5	5.33	5.10	7.8	7.27
Grade 6	7.95	8.9	7.11	7.5
Grade 7	7.64	8.4	9	9.8

Note: Families were classified as 4 or less members and greater than 4 members.

From Table 3, it can be seen that in the lower grades (4 and 5), the number of people living in a student's household is directly proportional to the number of marks scored. For grade 4, the difference in scores is less than half a mark (exactly 0.31), and for grade 5, this decreases further, becoming a difference of 0.23. The case for the upper grades (6 and 7) is the opposite, with more family members resulting in lower scores compared to students with fewer members in their families. For grade 6, the margin was extremely low, being 0.05 and for grade 5, the difference is larger, being 0.64. For the higher grades, since parents have limited resources, students might not be getting any additional coaching or tutoring help from parents or tutors. Alternatively, they might be forced to divert their time away from preparations and instead focus more on family chores. This could reduce their available time for studying, homework, etc. Therefore, they probably fall behind when it comes to schoolwork. [7][9][14] For the younger grades, however, the sole two explanations can be that they are either a) more focused in class or b) have their older siblings helping them understand school material. [15]

Table 4. Effect of number of friends on mathematical performance

	Answers		Logic	
No. of friends	**>3**	**<=3**	**>3**	**<=3**
Grade 4	4.75	3.67	6.25	5.89
Grade 5	5.3	4.88	8.4	6.71
Grade 6	9	8.09	N/A	N/A
Grade 7	8	7.45	9.125	9.18

Note: We classified a small number of friends as 3 or less members and larger friends as greater than 4

From the table above, the trend is similar for all grades. In all grades, the more friends a student has, the better the performance. The difference between the scores is about 1, but the gap gets consistently smaller as you go up in grades, with grade 7 only having a gap of 0.55. In grade 4, the gap is very large, being 1.08 marks; in grade 5, it is further decreased being 0.42. In grade 6, the gap again becomes larger, being 0.91, and lastly, in grade 7, as mentioned, the gap decreases to 0.55. Studies have shown that friends tend to think alike and that friends can be an academic motivator for students. [16]

Table 5. Effect of external tutoring on academic performance.

	Tutoring		No Tutoring	
	Sample size	**Score**	**Sample size**	**Score**
Grade 4	1	2	12	4.17
Grade 5	8	6	19	4.63
Grade 6	3	7	26	8.42
Grade 7	3	9.67	24	7.54

Scores of students in mathematics on the basis of students with access to or without access to tutoring.

For grade 4, we can see that there is inconclusive evidence due to the small sample size. In grade 6, students who had tutoring seemed to have a lower average than those without it, the total gap being 1.42 marks, a pretty large margin. However, in grades 5 and 7, the case seems to be the opposite. In grade 5, students with a tutor scored an average of 1.27 marks higher than those without. In grade 7, this gap is even larger, being 2.13 marks. Research on Sri Lankan students suggests that even with tutoring, there isn't a clear performance difference compared to those with no tutoring. [17]

The difference between the scores is about 1, but the gap gets consistently smaller as you go up in grades, with grade 7 only having a gap of 0.55. This implies that knowledge gaps start to increase as the students progress in grades.

From Figure 5, it can be seen that the gap in scores between students who ate breakfast and students who didn't eat breakfast is relatively large. There is around a 2-mark gap between them, with students who did eat breakfast scoring about 4 marks and students who didn't eat scoring close to 2 marks. Research shows that eating breakfast and school breakfast programs can positively affect a child's performance. Interestingly, this is predominantly evident in mathematics and arithmetic ability in undernourished children. [18] Typically, students who do not eat breakfast do so due to a lack of resources and money in their families.

From Figure 6, it can be seen that the gap in scores between Grade 5 students who ate breakfast and students who didn't eat breakfast is still relatively large. This is around a 2-mark gap between them, with students who did eat breakfast scoring about 5 marks and students who didn't eat scoring close to 3 marks. Adolphus et al. (2013), in their study, have shown that eating breakfast before school greatly enhances mathematical ability among children. [18]

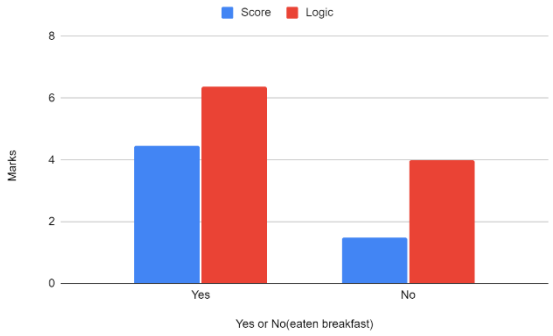


Fig. 5 Effect of eating breakfast before school on academic performance among Grade 4 students.

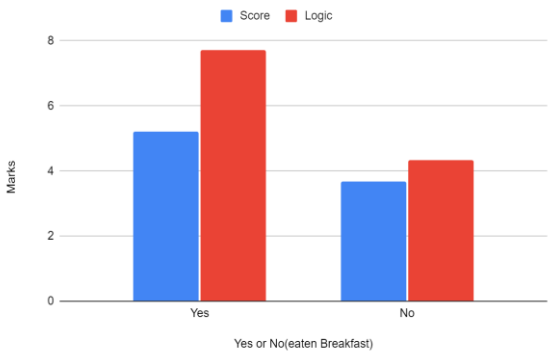


Fig. 6 Effect of eating breakfast before school on academic performance among Grade 5 students

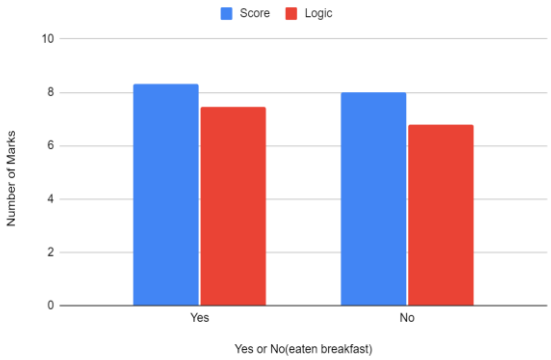


Fig. 7 Effect of eating breakfast before school on academic performance among Grade 6 students

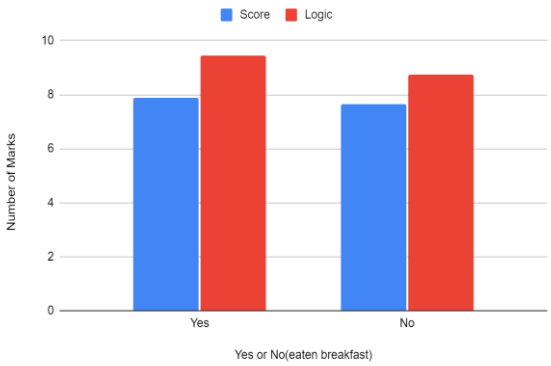


Fig. 8 Effect of eating breakfast before school on academic performance among Grade 7 students

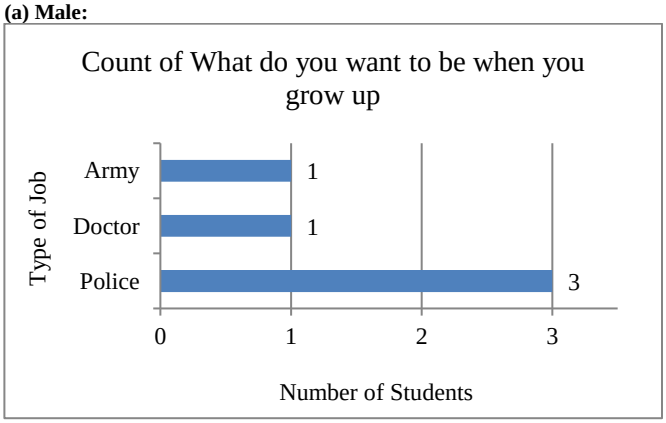
From Figure 7, it can be seen that the gap in scores between Grade 6 students who ate breakfast and students who didn't eat breakfast is now extremely small. This is around a 0.25 mark gap between them with students who did eat breakfast scoring about 8.25 marks and students who didn't eat scoring close to 8 marks. Papers have shown that eating breakfast before school, especially for undernourished children, has a highly positive effect on their academic performance [18]; however, this result now shows less in the current graph.

From Figure 8, it can be seen that the gap in scores between Grade 7 students who ate breakfast and students who didn't eat breakfast is now extremely small. This is around a 0.25 mark gap between them with students who did eat breakfast scoring about 8 marks and students who didn't eat scoring close to 7.75 marks.

For all four grades, no matter the sample sizes, eating breakfast before school seems to have a positive impact on academic performance at school. Research shows that eating breakfast at home and school breakfast programs can positively affect a child's performance. In his randomized controlled trials, McGregor (2005) provided further evidence that eating breakfast positively affects attendance and academic performance, especially in mathematics. [19]

What children want to be when they grow up based on gender

(a) Male:



(b) Female:

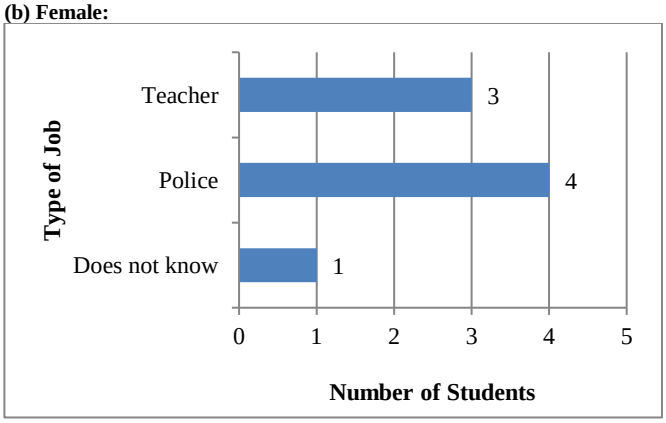
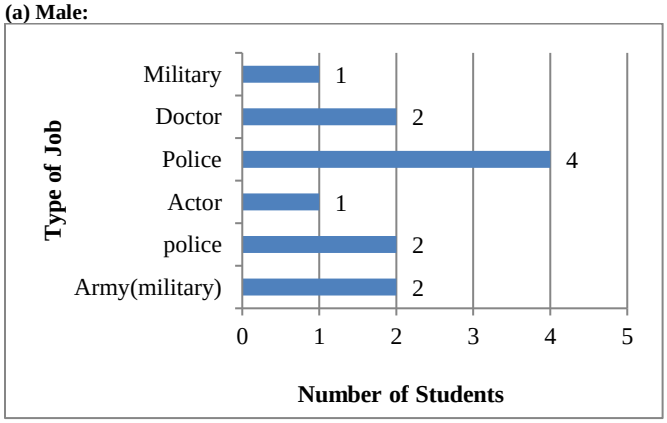


Fig. 9 Job Aspirations among children in Grade 4

From Figure 9a, it can be seen that in Grade 4, male students' primary interests in career options are either joining the army or becoming a police officer. This amassed a total of 4 out of 5 (80%) of the responses. The other response was becoming a doctor. From Figure 9b, it can be seen interestingly that the most popular job option for female students is a police officer, getting 4 out of 8 (50%) of the total responses. The next most popular career option was becoming a teacher, which got 3 responses, and one student did not know what she wanted to pursue. This was intriguing because all the other students in the grade had a definitive career plan. One observation is that most students choose a job from a narrow pool of options. This is possible because they have limited exposure to all the career options available due to being in a lower SES. Police officers may be a popular choice due to Indian media outlets, which highlight this profession in movies, TV shows, and the news. [20] Doctors may be another popular choice, probably due to either personal experience visiting a doctor or doctors being held in high regard in society. Teachers, of course, play a prominent role in the everyday lives of students, and it is not surprising that students would choose this career. Sometimes, such role models are shaped by two factors: first, parents and larger family, and second, teachers.

(a) Male:



(b) Female:

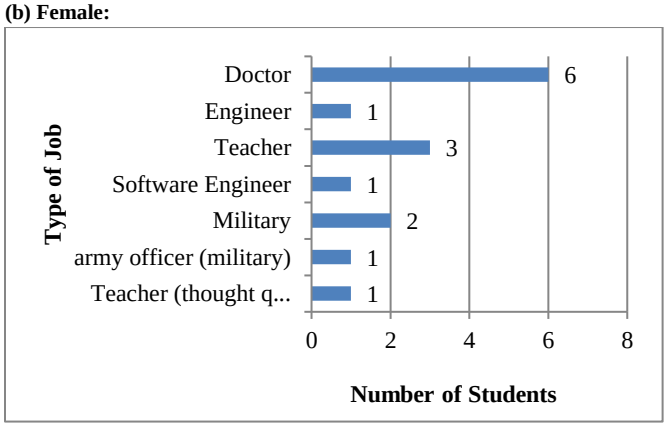
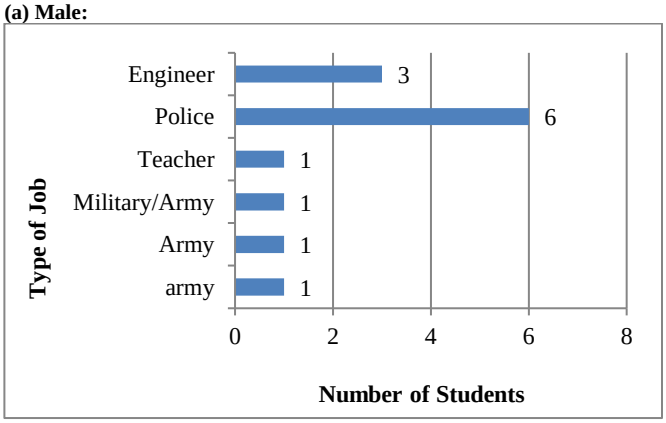


Fig. 10 Job Aspirations among children in Grade 5

From Figure 10a, it can be seen that in Grade 5, male students' primary interest in a career option is becoming a police officer. A total of 4 out of 12 (33.33%) students gave this response. This is followed by joining the military, which was 3 out of 12 (25%) of the total responses. These responses are similar to those of Grade 4. From graph 10b, we can see that female students are primarily interested in becoming

doctors. This amassed a total of 6 out of 15 (40%) of the responses. This is followed by joining the military and becoming a teacher, each getting 3 out of 15 (20%) responses. As mentioned earlier, the aspiration to become a police officer or join the military is probably due to the Indian media narrative, in which these careers are prominently featured. [20] Becoming a doctor might be perceived as a suitable career aspiration because they are often held in high regard in society. Similarly, teachers play a prominent role in the everyday lives of these students and serve as primary points of aspiration among students.

(a) Male:



(b) Female:

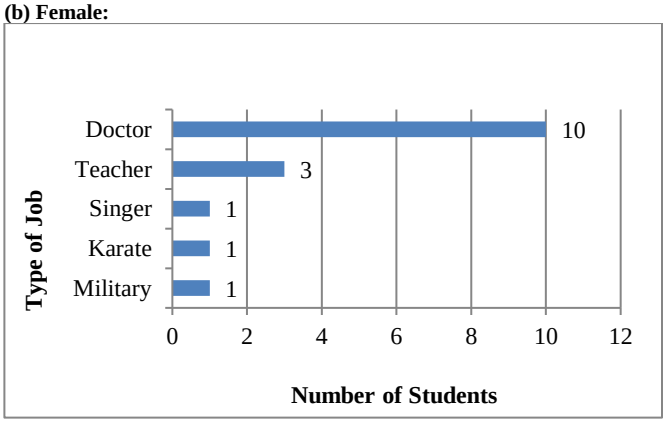
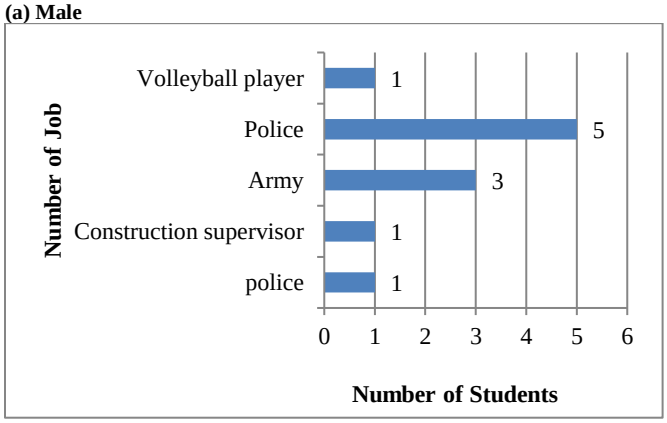


Fig. 11 Job Aspirations among children in Grade 6

From figure 11, it can be seen that the students of Grade 6 seem to be aware of more career choices as compared to students of lower Grades 4 and 5. Figure 11a shows that the most popular career option in Grade 6 males is yet again becoming a police officer, with a total of 6 out of 13 (46%) responses. This is followed by becoming an engineer, a new job option that wasn't present in the lower grades. Figure 11b yet again shows that becoming a doctor is the most popular career option amongst female students in grade 6, with 10 out of 16 (63%) responses. This is followed by a teacher, with 3 out of 16 (19%) responses. As mentioned earlier, the aspiration to become a police officer or join the military is probably due to seeing them in Indian media. [20] Most students, of course, have personal experience seeing doctors and teachers in their daily lives, so this career choice is fathomable. Engineering is a new career option that students in Grade 6 chose, probably encouraged by parents. It should also be noted that the one odd response indicating 'karate' or 'singer' is possibly due to the students having recent volunteer teachers teaching them taekwondo and singing.

(a) Male



(b) Female

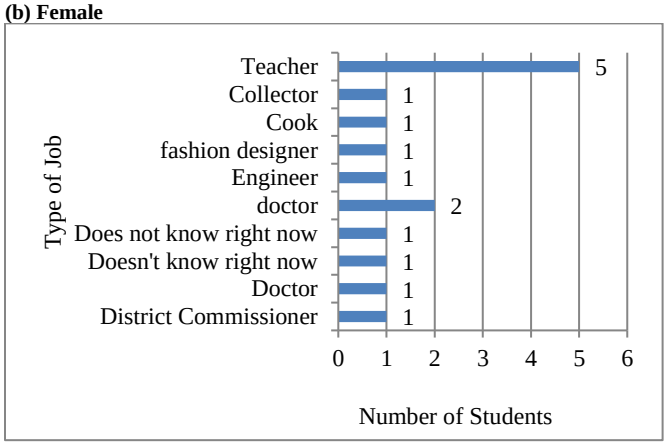


Fig. 12 Job Aspirations among children in Grade 7

The career option pool seemed to have expanded a bit more in Grade 7. We can see from Figure 12(a) that the most common job option amongst males is police, with 6 out of 11 (55%) of the responses. This is trailed by joining the army, with 3 out of 11 (27%) responses. It should be noted that the student who indicated "construction supervisor" did so as his father works as a construction supervisor at a local construction site.

For females, graph 12(b) shows that the most common job option was teaching, with 5 out of 15 (33%) of the total responses. This is followed by the aspiration to become a doctor, with 2 out of 15 (13%) of the responses.

Overall, the study of Grades 4, 5, 6 and 7 shows that the most common job aspirations are either becoming a police officer, teacher or doctor. Teachers and doctors are understandable since these children interact with these

professions every day. However, the reasons for wanting to become a police officer are less obvious. One plausible explanation may be that the Indian media portrays them as heroes who defeat criminals and maintain law and order in society. Studies have shown that Indian movies influence career choices, especially among the youth. [20]

A recent article stated, "Whenever a Bollywood movie with the protagonist playing the role of a police officer is announced, the image created in front of us is that of a person dressed in khaki (color of the uniform) with dark glasses and maybe a mustache or something defining him, who can beat up 50 people at a time without breaking a sweat!". [20] All of this could contribute to choices in impressionable younger students.

5. Statistical Analysis

This section shows the results of the t-test and ANOVA performed on the data.

5.1. Family Size

Table 6. Independent t-test analysis of family size data

		t	df	p	Cohen's d
Total Answer	Equal variances	0.55	94	0.583	0.12
	Unequal variances	0.52	58.49	0.603	0.11

Null Hypothesis: There is no difference between the <=4 and >4 groups with respect to the dependent variable Total Answer

Alternate Hypothesis: There is a difference between the <=4 and >4 groups with respect to the dependent variable Total Answer

There are no significant differences in total answers for people with fewer family members and those with more family members. Hence, the Null Hypothesis is accepted.

5.2. Number of Friends

Table 7. Independent t-test analysis of friend data

		t	df	p	Cohen's d
Total Answer	Equal variances	1.07	94	0.287	0.23
	Unequal variances	1.15	89.15	0.254	0.24

Null Hypothesis: There is no difference between the >3 and <=3 groups with respect to the dependent variable Total Answer

Alternate Hypothesis: There is a difference between the >3 and <=3 groups with respect to the dependent variable Total Answer

There are no significant differences in total answers for people with less friends and more friends. Hence, the Null Hypothesis is accepted.

5.3. Eating Breakfast Before School

Table 8. Independent t-test analysis of eating breakfast before school

		t	df	p	Cohen's d
Total Answer	Equal variances	-0.01	94	0.995	0
	Unequal variances	-0.01	30.98	0.995	0

Null Hypothesis: There is no difference between the YES and No groups with respect to the dependent variable Total Answer

Alternate Hypothesis: There is a difference between the YES and No groups with respect to the dependent variable, the Total Answer

There are no significant differences in parameters YES and NO. Hence, the Null Hypothesis is accepted.

5.4. Effect of Gender on Mathematics

Table 9. Independent t-test analysis of the effect of gender on numeracy

		t	df	p	Cohen's d
Total Answer	Equal variances	0.74	94	0.463	0.15
	Unequal variances	0.73	85.94	0.467	0.15

Null Hypothesis: There is no difference between the Female and Male groups with respect to the dependent variable Total Answer

Alternative Hypothesis: There is a difference between the Female and Male groups with respect to the dependent variable Total Answer

There are no significant differences in parameters, male and female. Hence, the Null Hypothesis is accepted.

5.4. Effect of Grade on Numeracy

Table 9. One-way Analysis of Variance of numeracy in different Grades

	Sum of Squares	df	Mean Square	F	p
Grade	272.54	3	90.85	13.03	<.001
Residual	641.42	92	6.97		
Total	913.96	95			

The p-value is < 0.05 for the analysis. Hence, the Null Hypothesis is rejected; this means that there is a significant difference between the scores of scholars from Grades 4 and 6, 4 and 7, 5 and 6 and 5 and 7.

6. Limitations

The only limitation was that the total sample size was small, being a total of 96 students.

The poor numeracy skills among these students could be due to a plethora of reasons. These may include a teaching environment of fear rather than learning, not having the money and resources to afford tutoring, and maybe even not eating breakfast before school. The main thing that was found in these grades was that concepts were not solidified before moving on. For example, they weren't able to do addition without the use of their fingers and toes to count. They would even use tally marks to subtract really large numbers. These all lead to one main change that needs to be done: changing the style the teachers are teaching.

7. Conclusion

From the data collected, it can be seen that these students have not been taught a method that is effective for them and, therefore, do not understand most of the material. From figures 1-4, it is seen that there is a gender gap favoring males, but that slowly starts to shrink as the children grow older. Figures 5-8 show that no matter what grade it is, students who ate breakfast before attending school achieved better scores. Figures 9-12 show that students' views about what they want to be when they grow up start to broaden when they grow up. However, the majority of children want to work for the police or army. Table 3 shows that the number of family members a child has is not a very significant demographic factor. Table 4 shows an interesting correlation that shows that friends are always academic motivators. Table 5 shows that tutoring is not representative due to the small sample size of students who do have external tutors. The next step that would be taken is to implement interventions in the form of non-traditional pedagogical methods. Overall, there are several areas in which these students can improve.

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