Significance of Affective Factors in Mathematics Learning of Low-achievers

An Analysis of Barriers in High School Mathematics Achievement from Kerala

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Abstract

This study administered a questionnaire on classroom and instructional factors, learner cognitive and affective factors and familial–parent relational factors affecting mathematics learning, and an achievement test in mathematics to 720 Grade 9 students of Kerala, to identify barriers that interfere with their achievements in mathematics. Chi-square analyses of the frequencies were followed up through comparison of proportions, and calculation of Risk Ratio and Odds Ratio. The findings indicate that, as against the customary belief that it is the learner-cognitive, classroom-instructional, and parental active involvement and support that distinguishes low–high achievement continuum in mathematics, it is infact the affective environment in school and at home and the related beliefs in the learner that make difference between high and low achievers in mathematics. The study implies that schools with large share of low-achievers in mathematics need to realise that students' performance cannot be raised in the long run as long as the focus is mainly on curricular and instructional factors and classroom management techniques.

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Introduction

Learning and achieving in mathematics continues to be a problematic area for students in Kerala, like elsewhere in the country and across the globe. Among high school students in Kerala, reportedly, 88 per cent selected mathematics as the most hated subject as they feel difficulty in understanding it; whereas only 6 per cent mentioned they like mathematics. They also attribute teacher or instructional factors for feeling difficulty in understanding the subject. For one-fifth of them, mathematics is a very difficult subject and more than half face medium-related difficulties. About 42 per cent fail to identify the ways to solve problems provided in their textbook. These students reportedly use blind strategies and hold less adaptive self-efficacy and epistemological beliefs in mathematics (Gafoor and Kurukkan, 2015).

Significant factors influencing achievement in mathematics include learner factors, curriculum factors, instructional strategies and methods, school context and classroom facilities, and home factors. For sorting out achievement challenge, especially so in mathematics, more consideration is given to school and instructional factors, learner cognitive factors and parental support and assistance. Rather less and irregular attention is paid to the affective experiences, socio-emotional aspects of teacher–student relations and peer relations in and out of classrooms. Taking the opinions of students on what factors they perceive as limiting their achievement in mathematics, is important. Hence, this study counts on learner perception of both cognitive–instructional and affective relational factors in the learner in relation with their teachers and peers and parents that co-occur with low achievement in mathematics of high school students of Kerala. Cognitive abilities of the students and their family background are important predictors of achievement. Recently, affective variables have emerged as salient factors affecting success and persistence in mathematics (Singh, Granville and Dika, 2002). Investigating affective factors responsible for low achievement will contribute to better understanding of how cognitive factors affect mathematics learning as well (McLeod, 1992). Further investigation of these three factors will enable policy-makers, curriculum-makers, instructional designers, school administrators and mathematics teachers to work towards improving mathematics instruction.

Learner Affective Factors and Mathematics Achievement

In the total variance in mathematics achievement, 68.8%, 14.2% and 17.0% respectively are effected by factors related to student, classroom and school levels (Kiwanuka et al., 2015). Traditionally, student factors denoted cognitive factors.

The affective domain is not even clearly defined. The main aspects of the affective domain, particularly in relation to mathematics education, are beliefs, attitudes and emotions including mathematics anxiety (Grootenboer and Marshman, 2016). Students' belief about mathematics and about themselves play an important role in the development of their affective responses to mathematical situations. Likewise positive and negative emotions, and positive or negative attitude towards mathematics are part of it (McLeod, 1992).

A major aspect of students' belief is self-concept. Students' self-concept and expression of confidence in learning mathematics are significant predictors of their performance. Self-concept is also associated with other affective dimensions of mathematics like perceived importance of mathematics (Kupari and Nissinen, 2013). Mathematics achievement is closely related with self-concept, academic self-concept and attitude towards mathematics (Wong, 1993). Another belief area known to affect mathematics learning is mathematics self-efficacy. Mathematics performance is correlated moderately with mathematics self-efficacy, as both are related to the attitude towards Mathematics. Mathematics self-efficacy has supremacy over even mathematics performance and achievement and in predicting and choosing further mathematics-related programmes too (Hackett and Betz, 1989). There is positive correlation of mathematical achievement with perceived usefulness of mathematics (Khine, Al-Mutawah and Afari, 2015) and students' perceived confidence (Bouchey and Harter, 2005; Grootenboer and Hemmings, 2007). There is high relationship between the anxiety, a debilitating emotion, and self-confidence measures (Goolsby, Dwinell, Higbee and Bretscher, 1988). Other affective determinants of mathematics achievement include students liking mathematics learning (Khine et al., 2015). A third category of affective factor influencing mathematics achievement is attitude which is extensively studied for long. There is strong positive correlation between mathematics attitude and mathematical achievement (Grootenboer and Hemmings, 2007). Attitudinal factors in mathematics are highly important in mathematics education because these variables are amenable to change by educational interventions.

School and Classroom Experience Differences in Mathematics Learning

It is known that attention should be given to school context and facilities to improve students' mathematics achievement. Though extent and type of influence may vary in different contexts, school differences explain variance in mathematics achievement in countries across the globe (Shin, Lee and Kim, 2006). School contexts like features of the school building,

facilities and student strength of the school and classes (Sa'ad, Adamu and Sadiq, 2014) influence the achievement of students. Classroom physical environment, i.e., lighting, temperature, ventilation system, size of the room, has a significant positive effect on the efficiency of instruction and learning activities. Unconducive physical environment results in fatigue and frustration among the students (Suleman and Hussain, 2014).

Instructional strategies and methods, teacher competency in mathematics education, and motivation or concentration (Saritas and Akdemir, 2009) also affect mathematics learning. However, there is an emerging recognition that affection seems to be the single most important characteristic that should be used to define school, or a classroom environment, in particular (Pooja and Shraddha, 2015). There is a strong consensus that interacting with the teacher leads to enhanced academic performance, motivation and attitude (Winheller, Hattie and Brown, 2013). While student's motivation and negative class atmosphere significantly affect achievement, effect of positive teacher–student relations on achievement could not be confirmed (Shin et al., 2006) by all.

A disruptive classroom climate can hinder the learning process and lower the achievement of the whole class, irrespective of the behaviour of any individual student. Student reports of classmates' disruptive behaviour are negatively related to student achievement, even when controlling for student, classroom and school characteristics, including students' prior achievements (Blank and Shavit, 2016). Disruptions not only damage students' confidence and trust in teachers (Kitsantas, Cheema and Ware, 2011) but can also lead to negative teacher attitude towards the classroom (Blank and Shavit, 2016). Ill-equipped teachers, poor teaching methods, inadequate teaching materials were some other causes of poor performance in mathematics (Sa'ad et al., 2014). Factors contributing to poor performance include understaffing, inadequate teaching/learning materials, lack of motivation and poor attitude by both teachers and students, and retrogressive practices (Mbugua, Kibet, Muthaa and Nkonke, 2012).

Supportive instructional discourse that focus on student understanding, student autonomy and motivation affect self-regulation and positive coping (approach behaviour). Motivational support provided through instructional practices, might be related to student outcomes in high-mastery/high-performance classrooms (Turner, Meyer, Midgley and Patrick, 2003). Positive teacher–student relationships are classified as having the presence of closeness, warmth and positivity and are known to affect student's beliefs, emotions and attitude. Positive relationships with teachers is a secure base for students to academically and socially explore the classroom and school setting, to take on academic

challenges and to work on social–emotional development. Positive teacher–student relationships thus help in relationships with peers, and developing self-esteem and self-concept. Secure relationship also communicates academic expectations and how to achieve these expectations. Students in low-income schools can especially benefit from positive relationships with teachers. Positive behaviour of their teachers correspond with academic achievement (Shah, 2011), through students' motivation and desire to learn.

Positive, warm and close relationship with their teacher motivates students to engage more in school and thus improves their achievement (Hughes, Cavell and Wilson, 2001). Students' motivation to learn is greatly helped by a caring and supportive teacher. Motivation is closely linked to students' perceptions of teacher's expectations. Educational expectations of middle and high school students shape from how they perceive their teachers' expectations. If students perceive high expectations from their teachers, they are motivated to meet those expectations and perform better academically; than their peers who perceive low expectations from their teachers (Muller, Katz and Dance, 1999). Expectations are important as they influence motivation and thus academic achievement. The element of student closeness was the highest, followed by cooperation, fairness, teacher support and involvement. Nidzam, Kamsiah and Lilia (as cited in Adnan, Abdullah, Puteh, Ahmad and Maat, 2014) suggest that a conducive learning environment promotes learning and students' development, which includes intellectual activities, friendship, cooperation and support.

Thus, effective classroom, environments are characterised by the following: (1) students help and support one another (Student closeness), (2) teachers helping and supporting students, and paying attention to students' problems (Teacher support), (3) students interested to pay attention, participate in classroom and work with other students (Involvement), (4) students cooperating with one another during activities (Cooperation), and (5) teachers treating all students equally, including giving compliments, asking questions and providing opportunities to participate in discussions (Fairness) (Fraser, 1998, cited in Adnan et al., 2014). Student closeness, involvement and cooperation can contribute to achievement in mathematics. Students perform better when they are positively influenced by their classmates and/or schoolmates. Peer support is expressed in study groups, discussion, advice and encouragement. Achievement of one's peers is positively correlated with a student's performance and such relationship is causal. That is, the improvement in peer quality enhances a student's performance (Kang, 2007).

Home-related Factors in Mathematics Learning

Parents and home are part of students' existence. Calls for parental involvement in schooling are not new. Parental involvement represents many different behaviour and practices of parents in relation to their children's education. They include parental attention to the children's basic needs; parental encouragement towards learning; parental aspirations for their children's academic achievement; communicating such aspirations to their children; parents' communication with children about school; parents' participation in school activities; parents' communication with teachers about their children; parents setting physical and other facilities for learning; and parental rules imposed at home that are related to education.

Parental assistance is related to performance of their children in mathematics. Family's socio-economic background had a significant effect on students' achievement in Korea and Finland (Shin et al., 2006). Self and parental expectations were the most influential factors among the affective variables (Wong, 1993). Parental assistance in solving mathematics problems at home is related to the performance of their children in mathematics (Imam and Singh, 2015). Parental support realised through payment for extra tuition, buying textbooks, encouragement to work hard, involvement in activities such as attending Parent–Teacher Association meetings, helping with homework and counselling relate positively with students' performance in Mathematics (Kiwanuka et al., 2015). Children who received more support and stimulation at home and whose parents had higher quality interactions with the school, had higher quality relationships with their teachers (O'Connor, 2010). Though parental support is important for students' achievement, what form it needs to take is not very clear. Improvement in students' achievement when parents allocate time for homework and monitor it, may be less than generalisable (Kiwanuka et al., 2015). Nevertheless, achievement gaps diminished with the increase in availability of homework resources (Kitsantas et al., 2011). Parental involvement was positively related to procedural mathematics achievement and negatively related to mathematics anxiety (Roberts and Vukovic, 2011). Also, there was positive correlation between the home environment and attitudes of the students towards mathematics (Mahanta, 2014). Among parental involvement factors, parental aspiration or parental expectation for children's education has the strongest relationship with academic achievement. Among these small to moderate yet practically important relationships, parental home supervision has the weakest relationship (Fan and Chen, 2001).

A congenial home environment is an essential factor in moulding the appetite of the students towards mathematics, which influences their overall academic achievement in the long run. Despite this, as with school and learner factors, relative importance of direct instructional and indirect nurturing and supportive roles of parents in mathematics learning is not yet clear.

Research Questions

What factors in schools, learners and at home are associated with low achievement in mathematics of secondary school students of Kerala? Do affective factors in teacher–pupil relations and peer relations match with school-instructional factors in being barrier for achievement in mathematics of these students? Whether students' self-belief, emotions and attitudes are more than self-perceived cognitive abilities in impacting students' low achievement in mathematics? Do more affective parent-relational factors than direct parent involvement factors impact low achievement in mathematics of their children?

Methodology

Descriptive Survey procedure comprising questionnaire and achievement test and percentage analysis and chi-square test of independence were employed.

Research Instrument

Questionnaire on Factors affecting Mathematics Learning (Mumthas, 2016) was used for finding out the various factors affecting mathematics learning. The questionnaire took students' response (Yes/No) on an array of 87 factors related to: affective relation with teacher (16), classroom (16) and instructional (23), learner cognitive and affective factors (13) and familial-parent relational and parent involvement factors (19).

The second instrument, Test on Achievement in Mathematics for Grade 9 (Mumthas, 2016), is a test with 60 multiple-choice questions for measuring achievement among secondary school students in Kerala. It has questions on concepts taught in grades lower than 9, and hence tests achievement of mathematics concepts up to Grade 9. The sample group was categorised into high and low achievers by using first and third quartile as cut points.

Participants

The initial sample of 720 Grade 9 students (327 boys, 393 girls) were drawn from eight government (388 students) and five government-aided schools (332 students) of Kerala, India. The analysis sample for identifying the barriers for mathematics achievement included upper (Mathematics Achievement > 38, n=183) and lower quartile groups (Mathematics Achievement <24, n=194) based on the achievement test score (377 students; Boys=166; Girls=211).

Statistical Analysis

Chi-square analyses were followed up by comparison of proportions, and calculation of Risk Ratio and Odds value. For every factor identified as significant barrier in high school mathematics achievement, relative risk (RR) of 1.22 to 1.87 is taken as small effect on achievement and above 1.87 is taken as moderate effect (Olivier, May and Bell, 2016) on achievement.

Results and Discussion

Out of the total 87 factors, 43 factors significantly distinguish high and low achievers and the remaining 44 factors do not significantly distinguish between high and low achieving groups. Seven out of 16 factors in affective relation with teacher, significantly associate with low achievement in mathematics. Eight out of 16 classroom socio-emotional factors and 8 out of 23 cognitive-instructional factors significantly associate with low achievement. Home and parent involvement factors that associate with low achievement in mathematics, three are clearly affective-relational and one is physical facility and only two out of six of the remaining are on direct help in mathematics learning. However, of the nine remaining home and parent involvement factors, only one is clearly affective, two are on parent-school relationships and six are regulatory in nature.

Teachers' negative emotions that too from concealed category than expressive and positive affection are decisive in students' achievement in mathematics.

Teachers neglecting the children, belittling them, or finding fault in them have high negative impact on students' achievement in mathematics, but they affect relatively fewer students, whereas low teacher expectations and students being fearful of teachers have significant negative impact, though of relatively smaller size, on mathematics achievement of around one-third to one-fourth of students. Teachers being angry or scolding the children also have significant negative impact, of relatively smaller size, on mathematics achievement of around one-tenth of students.

Lack of other more open affectionate behaviour by teachers are reported by students, however these have no significant impact on students' achievement in mathematics. Majority of students are not enquired about learning facilities at home, by their teachers. More than one-third of students feel that their teachers provide no individual attention and do not behave in a friendly way, and that they fear clarifying doubts with mathematics teachers. More than one-fourth students report that their teachers do not ask for reason when they avail leave from school and that teachers do not like them. Between 10 to 20 per cent students feel that teachers do not pay attention to them during the lessons or express happiness when they perform better in mathematics and that they even laugh at them for committing mistakes.

Instruction and assessment by teacher with focus on structuring and anchoring the conceptual grasp and skills for all learners rather than drilling classroom group organisation and guidelines will help to improve mathematics achievement.

The instructional acts by teachers which help structure and anchor what has been learnt, like summarising the major concepts and helping with unit end exercises, has moderate impact on mathematics achievement of around two-third to one-third of students. Not engaging slow learners in learning activities, not relating the topic to their life, or considering them while pacing the lessons or clarifying their doubts at the end of the lesson, has moderate impact on achievement in mathematics of nearly one-third of students. Lack or faulty use of blackboard also has moderate negative impact on around one-fifth of students.

Students perceive that teachers endorse rote learning of formulae and are indifferent to co-operative and self-regulative learning strategies.

Other instruction-related harmful behaviour of teachers are also widely perceived, but they fail to obtain significant association with the level of student achievement. Overemphasising the formulae while teaching, appointing select few students as group leader, not ensuring participation (of all) in group works, are perceived by large share of students. Their teachers not checking if they have learnt the topic of the day, not checking homework, not reviewing the topics before exams, are perceived by more than one-fourth of students. Teachers not asking them questions, not guiding how to learn mathematics, not providing necessary instructions on group work, not giving opportunity to clear doubts are also perceived by one-fifth of students. Not praising them if they solve problems correctly, not allowing time to copy the sums from the blackboard, not explaining the lessons with examples, not explaining difficult lessons many times, are reported by around one-tenth of students.

Obligatory physical settings impact students' learning in mathematics than social and intellectual milieu of the classroom.

Nearly half of the students are negatively impacted especially by noise and to a lesser extent by lack of seating facilities. Classroom lighting, isolation in group work, and frequent absence from school have high negative impact on mathematics achievement of around one-fourth of students. Isolation from peers who are better achievers in all areas of learning has moderate negative impact on mathematics achievement of more than one-third of students.

But lack of many other factors, that follows, which may enrich the classroom academically and socially were found not to impact mathematics achievement level of

students. Majority of students do not have specially allotted library time for mathematics learning, nor do they borrow maths related books from library, but one-fifth students have not seen maths related titles there. About one-third of students have friends who laugh at them for paying more attention to learning and about one-fifth have friends who do so for committing mistakes in maths. About one-tenth of students perceive lack of friends who help in learning. One-fifth of students do not like group work and one-sixth feel having to do everything if they were made group leader.

Feeling of difficulty in mathematics and many allied self-belief impact mathematics achievement of substantial number of students.

One in four students do not like mathematics and about one-fifth of them feel that it is useless for life; and this has a major effect on their low achievement status in the subject. Feeling maths as difficult, difficulty to memorise and to comprehend questions is reported by two-third of students and each has significant but small association with math achievement level. More than one-third of students feel they cannot learn maths very well, are not learning maths everyday, and neither can they comprehend the maths textbook. All these aspects have significant, though small influence on their maths achievement.

Majority of students feel unable to follow lesson even when a single class was missed (yes%=81.3) and do not read maths textbook (yes%= 52.9), and a considerable portion feels that maths required for daily life should only be learnt (yes%=20.1). But these two observations did not produce a significant change in student achievement levels.

More than home–school contact, physical and psychological environment at home characterised by authoritative parenting impact students' achievement in mathematics, of a significant number of students.

Relatively lesser number of students perceive home-related barriers to mathematics education; and irrespective of the extent of their prevalence they have small impact on maths achievement even where significant. Other than 'No one at home to teach maths' (46.9%) and 'Receiving no help from home for learning maths' (25%), barriers like 'Parents not warning even if not studying' (19.3%), and 'No one at home asking to study' (15.3%), 'Not having facilities at home to learn away from usual distractions' (13.9%), 'Parents suggesting to miss school other than for illness' (12.5%), and 'Parents enquire reasons if scoring less in maths' (12.1%), are perceived by less than one-fourth of students. Other barriers like 'Parents exhorting the importance of the study', 'Family problem', 'Feeling parents don't like them' are even lesser.

More explicit parental intervention or lack of it did not produce significant

change in students' maths achievement level. In the case of majority of students, elders do not keep a watch while they learn maths (yes%= 67.2) and they feel difficulty as others watch TV while learning at home (yes%=57.8). About one-fifth of parents do not discuss learning with teachers (yes%=18.9). For around one-tenth of them, elders at home do not check answer scripts (yes%=9.3); nor do they warn when they score less (yes%=12.8) or reprimand them if they watch TV during learning hours (yes%=9.6). Only parents of a few students do not enquire about their learning progress (yes%=7.8) and do not attend PTA meetings (yes%=7.5).

Conclusion and Implications

Students with negative affect for mathematics tend to make negative appraisals of their ability and they tend to direct time and attention away from learning. These emotions distract students from approaching and solving the problem and make them focus on their failings instead. Negative affect for failure is more common in classrooms where mistakes are linked to lower ability (Turner et al., 2003). Parents' positive attitude about their children's education is even more important than their active instructional and school contact events.

A polite, loving teacher is preferred over the one who shouts and punishes children. It is important for teachers to be sensitive towards the needs of all children. To increase mathematics performance, teachers should focus more on enhancing the quality of learning and students' mathematics related affective experiences through acceptance and even appreciation of individual differences. Feelings of competence, self-determination and being connected to peers, need to be nurtured. When teachers form positive bonds with students, classrooms become supportive spaces in which students can engage in productive ways academically and socially.

Mathematics teachers need to create a classroom culture where students positively support each other for improving their mathematics performance (Kiwanuka et al., 2015). Students who have confidence and belief in their ability to control their engagement and learning activities, achieve more (Winheller et al., 2013; Kupari and Nissinen, 2013). Teachers should give special attention to students who have difficulty in making friends. It is important to teach some guidelines and social skills. Learning of weaker students is negatively affected as they tend to interact with other weaker students more closely than with stronger peers. In contrast, strong students are found to interact more closely with other strong students; hence their learning can be improved by the presence of best-performing peers (Kang, 2007). Guiding, encouraging and rewarding of student activity should be prioritised while teaching. Holistic development, not factual

information acquisition should be the goal of all teachers.

The feedback provided to students is very important in helping them maintain high and accurate self-efficacy beliefs. Feedback should be specific. A high rate of reprimands and low rate of praises have several negative effects. Teachers should regularly praise and encourage students for acting appropriately. Otherwise, positive student behaviour weakens for want of recognition. This may result in their eventually withdrawing from participating in the class or they may even avoid the maths class. Praise and other positive interactions between teachers and students are important. They remind the students about behavioural and academic expectations and give them clear evidence that he or she is capable of achieving those expectations (Mayer, 2000). The teachers should praise the students wherever possible without being too positive (Warwick, 2008). For every reprimand given, teachers need to have 3 to 4 positive interactions with the student (Sprick, Borgmeier and Nolet, 2002). Positive interactions might include focused, specific praise, non-verbal exchanges, smile or 'thumbs-up', encouraging note written on the student's homework assignment, etc. Such an encounter with a mathematics teacher, who embodies the joy of mathematics and encourages students to explore and experiment with mathematics, can affect students' feelings towards mathematics in a positive way. Such encounters are rare, at present. Hence, the teacher needs to be equipped with strategies for accommodating and teaching students with differences, vulnerabilities and disabilities.

Hence, the study recommends that barriers to mathematics learning need to be identified in local contexts of the school and learners. As negative encounters with teachers do affect mathematics learning, teachers need to allow student-choice in learning activities, enhance praise and other positive interactions. Teachers should use specific praise like encouraging notes written on the students' homework assignments and non-verbal exchanges that give students confirmation that he or she is capable of achieving teacher and curricular expectations, especially with students at risk in mathematics. Teachers should reduce the rate of reprimands and other negative feedback. Further, enhancing student self-esteem via feelings of competence, self-determination and being connected to others, is recommended. This requires facilitating students' holistic development (than fragmentary discipline-specific instruction of content and strategies) through adoption of strategies to meet students' interests, attitude and other intrinsic motivational, curriculum-based methods to stimulating social emotional development, and creating a psychological sense of community in the classroom. Some guidelines for

making friends and social skills may be taught. This also implies that teacher education should further strengthen strategies for accommodating and for teaching students to compensate for differences and weaknesses.

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