IMPROVING TEACHING AND LEARNING IN MATHEMATICS AND 21ST CENTURY COMPETENCIES AMONG MATHEMATICS LEARNERS IN THE JUNIOR SECONDARY CLASSROOMS

(A diagnostic study conducted in the Central Province of Sri Lanka)

By

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A study funded by the World Bank Accelerating Higher Education Expansion and Development (AHEAD) operation of the Ministry of Education, Sri Lanka.

Department of Education, Faculty of Arts, University of Peradeniya, Sri Lanka
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Abstract

Growing evidence from research, widespread public opinion, and educators themselves support the view that education systems, globally, are far from achieving the purpose of preparing children to adapt to the world of the future and empowering them to actively engage in making it better. Therefore, education needs fundamental reforms from top to bottom to prepare students for the 21st century. Reforms in education in Sri Lanka are frequently based on limited empirical evidence and participation of stakeholders at grassroots level. Our current circumstances require new models of education based on participatory approaches and research-based evidence to adapt to the demands of the 21st century. The current study is an attempt to provide such information where, we have focused on the issues of students' achievements in Mathematics and the need to instil 21st century skills among students, by exploring the reasons for poor achievements and identifying possibilities for improvement through appropriate interventions at classroom level using a Collaborative Action Research (CAR) approach. The study has been conducted in two phases. Phase 1 is a survey research study designed to diagnose the existing situation of students' mathematics achievements and the factors associated with teaching, learning, and students' achievements. Phase 2 is a CAR conducted in a small sample of schools involving mathematics teachers, In-Service Advisors (ISAs) and officers responsible for Mathematics education. This book focuses on the Phase 1, which addressed the following three questions. 1.What is the existing situation of Mathematics education in the junior secondary level in the selected province? 2. What are the key factors affecting teaching, learning and achievements in Mathematics in the provincial and classroom levels? 3. What interventions are necessary at distinct levels of the education system to improve teaching and learning mathematics and instilling 21st century competencies among students in the junior secondary level? The study employed a stratified random sample of fifty schools selected from the Central Province. Data were collected using questionnaires, interviews, and classroom observations. Fifty Principals, fifty teachers and 1371 students participated in the study. Data were analyzed using SPSS software and thematic analysis. Accordingly, it is found that 1. Student learning and achievements in mathematics in the selected province is affected by complex interaction of many factors related to the central, provincial, school and classroom levels as well as, students, teachers, parents, and home environments. 2. Teachers' classroom practices need to be improved in relation to effective classroom management, teaching learning strategies, providing safe and stimulating learning environment and adaptive teaching. 3. Improvement of student learning and teachers teaching should be given priority and to achieve this purpose a multilevel approach is necessary. 4.Teachers should be empowered to identify problems related to teaching and learning mathematics in their classrooms, and strategies necessary to address such problems, implement those strategies, monitor, and evaluate their effects on students' progress and remediation. In conclusion, we present five sets of recommendations (See details in Chapter 5), which are necessary to be implemented by the teachers, schools, teacher education and professional development programmes, National, Provincial, Zonal education authorities.

Key Words: Mathematics Education, Teaching, learning, Student achievements.

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List of Abbreviations

BEd	- Bachelor of Education
CAR	- Collaborative Action Research
CBAR	- Classroom-Based Action Research
CPD	- Continuing Professional Development
GCE (A/L)	- General Certificate of Education (Advanced Level)
GCE (O/L)	- General Certificate of Education (Ordinary Level)
GELCE	- General Education Leaving Certificate Examination
ICT	- Information Communication Technology
IEA	- International Association for the Evaluation of Educational Achievement
ISAs	- In-Service Advisors
KA	- Khan Academy
MoE	- Ministry of Education
NCTM	- National Council of Teachers of Mathematics
NEC	- National Education Commission
NEREC	- National Education Research Evaluation Centre
NIE	- National Institute of Education
OECD	- Organization for Economic Cooperation and Development
PBL	- Project-Based Learning
PDE	- Provincial Department of Education
PGDE	- Post-Graduate Diploma in Education
PISA	- Programme for International Student Assessment
QoT	- Quality of Teaching
SBPTD	- School Based Professional Teacher Development
SCI	- School Climate Index
STEAM	- Science, Technology, Art, and Mathematics
STEM	- Science, Technology, Engineering, and Mathematics
TEE	- Technology and Engineering Education
TIMSS	- Trends in International Mathematics and Science Study

Chapter 1: Introduction

1.0 Introduction

Education should endeavor to prepare children to adapt to the world of the future and to empowering them to actively engage in making it better. However, growing evidence from research, widespread public opinion, and educators themselves support the view that education systems, globally, are far from achieving this purpose. Students are often not prepared to succeed in todays, let alone tomorrows, world (Fadel et al, 2015). Therefore, education needs fundamental reforms from top to bottom to prepare students for the 21st century demands.

Reforms in education in Sri Lanka are frequently based on limited empirical evidence and participation of stakeholders at grassroots level. Our current circumstances require new models of education based on participatory approaches and research-based evidence to adapt to the demands of the 21st century. In the current study, we have included a diagnostic phase and a Collaborative Action research (CAR) phase, which focuses on the need for reforms in teaching and learning Mathematics to instill 21st century skills among students at the Junior Secondary classrooms in Sri Lanka. The study specifically attempted to provide useful evidence on teaching and learning of Mathematics at classroom level to inform education reforms and policy at distinct levels of the education system. The study has been conducted in two phases. Phase 1 is a survey research study designed to diagnose the existing situation of students' mathematics achievements and the factors associated with teaching , learning, and students' achievements. Phase 2 is a CAR conducted in a small sample of schools involving mathematics teachers, In-Service Advisors (ISAs) and officers responsible for Mathematics education. The study was initially planned to be implemented from January 2019 to December 2021. However, due to the prolonged school closures during COVID-19 pandemic in 2020 and 2021 the implementation of Phase 2 had to be extended up to the end of 2022.

1.1 The research problem and the rationale

Student achievements in Mathematics at the GCE(O/L) is at an alarmingly low level. For example, the analysis of GCE (O/L) results in 2015 sets out in Table 1 indicates that 70.13% students scored below 40 marks (DoE, 2016).

Table 1. 1 Frequency distribution of Mathematics scores at the GCE (O/L) examination (2015)

Class Interval	Frequency	Frequency Percentage	Cumulative Frequency	Cumulative Frequency Percentage
91-100	1568	0.40	393887	100.00
81-90	9884	2.51	392319	99.60
71-80	19072	4.84	382435	97.09
61-70	22683	5.76	363363	92.25
51-60	29277	7.43	340680	86.49
41-50	35169	8.93	311403	79.06
31-40	58214	14.78	276234	70.13
21-30	66732	16.94	218020	55.35
11-20	75450	19.16	151288	38.41
01-10	73160	18.57	75838	19.25
00-00	2678	0.68	2678	0.68

Source: Department of Examinations, Sri Lanka (2016)

However, the National assessment data sets out in Table 2 indicates that 50% of students scored below 47.5 marks and 25% scored below 35.0 marks for mathematics at national level after completing Grade 8 in 2014. The results of the National Assessment 2014 of Grade 8 students and the GCE(O/L) results of 2015 when compared together implicates a decline in mathematics achievements as students' progress from grade 8 to Grade 11.

Table 1. 2 Summary statistics of mathematics scores of Students completing Grade 8 in 2014

Province	Mean	Rank	Standard Deviation	Standard Error Of mean	Percentile (p_{25})= Q1	Median (p_{50})= Q2	Percentile (p_{75})= Q3	Skew ness
Western	55.49	1	20.73	0.08	37.61	55.00	72.52	0.00
Southern	53.66	2	21.44	0.11	35.02	52.51	72.62	0.21
Sabaragamuwa	52.35	3	19.46	0.11	37.42	50.02	67.51	0.18
Northwestern	50.99	4	19.58	0.10	35.02	47.53	65.21	0.31
Eastern	49.28	5	20.28	0.11	32.41	45.21	65.35	0.29
North Central	48.98	6	19.17	0.13	35.05	45.31	62.21	0.42
Uva	47.95	7	18.80	0.13	32.51	45.05	60.42	0.43
Northern	46.05	8	19.55	0.14	30.12	42.52	60.14	0.57
Central	44.96	9	18.77	0.09	30.02	40.01	57.51	0.68
All island	**50.87**		**20.29**	**0.04**	**35.02**	**47.51**	**67.51**	**0.29**

Source: NEREC (2015)

Moreover, according to National Assessment results, there are significant differences in Mathematics achievements among the provinces. Western province tops the rank, and the central province has the lowest rank (see Table 1.2). The median value of Western province is fifty-five while the median of Central province is 40. The above data indicates the grave situation of mathematics achievement at the junior secondary level and at the GCE (O/L) examination.

National Assessments have been conducted in Sri Lanka since 2002 and they produce a comprehensive analysis of students' achievements in four subjects that include first language (Sinhala and Tamil), Mathematics, Science and English at 4-year time intervals. The reports indicate disparities in relation to the subject disciplines, gender, provinces, school types, medium of instruction and urban rural location. However, follow-up studies to understand the reasons behind those disparities and to identify appropriate interventions to minimize such disparities at the classroom level have not been conducted. Furthermore, the National assessments are limited to measuring student achievements of selected subjects at regular intervals. They provide useful information for policy making to some extent but fail to explain the complexities of the practices at school and classroom levels that directly contribute to those achievements. Therefore, there is a need to conduct research that will illuminate the gray area of classroom practices that directly contribute to the improvement of Mathematics achievements and 21st century skills among students. Accordingly, in this study we wish to address the issues of low achievements in Mathematics and the need to instill 21st century skills among students, by exploring the reasons for low achievement and identifying possibilities for improvement through appropriate interventions at classroom level using a Collaborative Action Research (CAR) approach.

1.2 Scope of the Research

Key question to be answered in this research study is 'How can we improve teaching and learning of Mathematics at the junior secondary level of education in Sri Lanka for instilling skills of the 21st century among the students?'
To address the above key question following sub questions have been set:
Research questions

1. What is the existing situation of Mathematics education at the junior secondary level in the selected province?
2. What are the key factors affecting teaching, learning and achievements in Mathematics in the provincial and classroom levels?
3. What interventions are necessary at distinct levels of the education system to improve teaching and learning for instilling skills of 21st century among students?
4. How effective are the interventions implemented in the study in improving teaching and learning of Mathematics for instilling 21st century skills among students?
5. What are the implications of the findings of this research for policy, practice, and research in mathematics education?

Main purpose of this study is to identify reasons for existing situation in mathematics education at provincial level of education and to develop insights for improving teaching and learning through appropriate interventions designed to instill 21st century skills among students in Mathematics classrooms. To achieve this purpose following objectives have been set.

1. To develop an in-depth understanding of the reasons for poor achievements in Mathematics education at the junior secondary level of education in a selected province.
2. To bring about a positive change in the teaching, learning and assessment practices in the targeted classrooms through a CAR approach.
3. To empower teachers, officers and ISAs who participate in the CAR to identify problems in their own practices and to implement appropriate interventions to address those problems to improve their own professional knowledge and practices.
4. To generate research-based knowledge for improving policy making, curriculum designing, resource material production, teacher education and other practices in mathematics education in Sri Lanka
5. To improve the capacity of university researchers for knowledge creation and contributing to the social and economic development of the country by engaging in collaborative research to improve policy, practice, and further research in the field of education in Sri Lanka.

This book fully addresses the first two research questions mentioned in the above using the survey research conducted in the Phase 1 of the study. It also addresses the third research question using the findings of the first two questions and the extant literature:

1. What is the existing situation of Mathematics education in the junior secondary level in the selected province?
2. What are the key factors affecting teaching, learning and achievements in Mathematics in the provincial and classroom levels?
3. What interventions are necessary at distinct levels of the education system to improve teaching and learning mathematics and instilling 21st century competences among students in the junior secondary level?

The study was conducted in a stratified random sample of fifty schools selected from the Central Province.

1.3 Summary

In this chapter we have highlighted the need for developing 21st century skills among the students in Mathematics classrooms at the junior secondary level of Sri Lanka. We have also discussed the grave situation of Mathematics achievements at the junior secondary level in the

Central province and the need for understanding the reasons for such a situation and implementing appropriate interventions to improve teaching and learning in Mathematics classrooms. Finally, we have defined the research questions and objectives of the current study and briefly summarized the scope of the study. In the next chapter we will discuss the pertinent literature to orient the current study in the relevant national and international research context of mathematics education.

Chapter 2: Literature review

The purpose of this chapter is to peruse the pertinent literature on students' achievements in mathematics, factors affecting students' achievements in Mathematics at the junior secondary level and the importance of incorporating 21st century skills in the mathematics classrooms. The Chapter includes the following main sections.

1. Student achievements in Mathematics at the junior secondary level of education in Sri Lanka
2. Factors affecting students' achievements in mathematics
3. Mathematics curriculum at the junior secondary level of education in Sri Lanka and the need to incorporate 21st century skills in the teaching learning process.

2.1 Student achievements in Mathematics at the junior secondary level of education in Sri Lanka

Athurupane *et al*. (2011, p.85-87) review the achievements of students in mathematics, using information from the national assessment tests conducted by the National Education Research Evaluation Centre (NEREC), regarding learning outcomes of grade 8 students; the G.C.E. (O.L.) examination at the end of grade 11; and the G.C.E. (A.L.) examination at the end of grade 13 during the period of 2005 to 2008. The study reveals that the learning outcomes for mathematics in middle school (Grades 6-8) have improved during the period 2005 to 2008. Moreover, it reports the improvement in the G.C.E. (O.L.) pass rates in Mathematics from 2005 to 2009. Although there had been an improvement in the GCE O/L mathematics pass rates, the mean scores had consistently been low up to 2009 (32±2). The increasing trend observed in the achievement levels of grade 8 students was not reflected in the G.C.E. (O.L.) examination marks, and Athurupana et al suggest that it may be due to the standardization of results. Two factors have been identified in the report in relation to the mediocre performance in mathematics at the G.C.E. (O.L.) examination. Subject knowledge of teachers was one of the major factors and the other is the practice of automatic promotion in which the students were able to pass from one grade to another without being fully equipped with the skills necessary to be able to cope with the work in the higher grade.

The NEREC report on the national assessment during the period of 2013 -2015 had concluded that even though overall achievement of learning outcomes in mathematics was satisfactory, there is still disparities in achievement at the provincial level as well as in relation to location of the school and gender (NEREC, 2015 p. 178). It was revealed that the students' performance

in relation to the sub skills of procedures and problem solving has increased. The report identified this as a positive trend. But, on the other hand the knowledge of concepts has declined. The study suggests that more attention needs to be paid to the students' lack of conceptual knowledge because it will affect the other skills if this trend continues. (NEREC, 2015).

Against this backdrop following studies shed some light on the factors affecting students' achievements in Mathematics at the school, classroom, and individual levels.

Weerarathne & Chin (2018) intervene to improve the achievement of Mathematics of the ninth-grade students in Sri Lanka while using Khan Academy (KA) video tutorials in a blended learning environment and the study revealed that the use of KA tutorials would help for better achievement of Mathematics.

Bandaranayake & Turner (2018, p. 9) found a negative and statistically significant relationship between mathematics anxiety and mathematics achievement among G.C.E. (O.L.) students in Sri Lanka. Furthermore, it identified the anxieties related to attitudes towards learning mathematics having a more prominent effect and that as mathematics anxiety increases, mathematics achievement falls. The study also found that the congeniality of students' schools (how well resourced the school is) and parents' education levels also affect students' mathematics performance and levels of mathematics anxiety. Highly anxious mathematics students will require individualized interventions to mitigate their anxiety and thus prevent Mathematics anxiety having an adverse effect on their performance.

The above review indicates the needs to improve student learning by making interventions at classroom/individual level to reduce students' mathematical anxiety, improve conceptual understandings, school facilities and the use of digital technologies and parental support.

2.2 Factors affecting students' achievement in Mathematics

The literature reports several factors that affect students' achievement in Mathematics**.**

2.2.1 Student related factors

Student related factors are identified in the literature as one of the important aspects of mathematics achievement of students, which plays a vital role in the process of teaching and learning. A few previous research indicate that students' mathematics interest is still low because most of them have perceived that mathematics is difficult, boring, not very practical, and have many abstract theorems that were extremely hard to understand (Khasanah *et al.*, 2017). Literature also highlights that achievement in mathematics among school students is influenced by many factors (Callingham, 2014).

As one of the main factors related to student factors, students' mathematics anxiety is highlighted in the literature. Students' mathematics anxiety is considered as a fear or phobia

that produces ‘a negative response specific to the learning, or doing, of mathematical activities that interferes with performance’ (Whyte & Anthony, 2012). Mathematics anxiety can affect individuals in varying ways, inducing a cognitive, affective, or physical reaction. Mathematics anxiety, considered as a fear or phobia, produces a negative response specific to the learning, or doing, of mathematical activities that interferes with performance’ (Whyte, 2009, p. 4). Imre, et al (2020) identify that the classroom is a place where mathematics anxiety can develop. As Acharya, B. R. (2017), finds out, negative explanations about mathematics from the teacher’s side created frustration and anxiety in mathematics students. Therefore, the teachers must have an awareness and understanding of mathematics anxiety and develop an ability to assist mathematics anxious students (Yanuarto W., 2016). Furthermore, negative explanations from parents and other persons about mathematics also influence students’ mathematics anxiety (Acharya, B. R. 2017). Highlighting parents’ influence Else-Quest, Hyde, & Hejmadi, (2008), note that in the home, parents who themselves suffer mathematics anxiety can unintentionally transfer such anxiety to their children. Not only this, but if the parents apply a pressure on children also contribute to the development of mathematics anxiety (Fraser & Honeyford, 2000).

Lack of reasoning skill, which is an essential skill in Mathematics learning (Nunes *et al.*, 2007) of a student is also identified as another imperative student related factor related to students’ mathematics achievement. In a classroom, students need to encourage thinking and reasoning about mathematics, thus making communication, an essential practice and skill. Mansi (2003) states that students’ reasoning skills can be enhanced by placing students in situations in which they are able to make, refine, and test their own conjectures during elementary education. Moreover, teachers must develop in their classes a sense of community, so that students feel free to express their ideas honestly and openly without fear of being ridiculed where all individual students can present and explain the strategy, they used to solve a problem orally and in writing with their reasoning (Marques, 2008).

Relating to students’ mathematics achievement, prior knowledge of students is identified as another aspect of student related factors which means the previous knowledge of the students towards mathematical contents. The prior knowledge is imperative as it helps student to understand new lesson especially when they are activated and they serve as prerequisite information (Oyinloye and Popoola, 2013). Those students who have lack of sufficient prior knowledge did not want to learn and could not get success in the assessments (Acharya, B. R. 2017).

Lack of Student’s effort is also identified as a student related factor regarding a student's mathematics achievement. Emphasizing the importance of students’ commitment towards mathematics learning, Acharya, B. R. (2017) reports that mathematics achievements determine students' effort in mathematics learning. In research literature, this factor is described differently. For instance, Barczi, (2000) points out that the students do not read questions properly, instead just have a quick look, see some numbers, but skip over the important details, which results in them answering a wrong question. Henningsen& Stein (1997) identify that less engagement of students during the mathematics lesson is a reason for their lower achievements.

They highlight that, without engaging in active processes during classroom instruction, students cannot be expected to develop the capacity to think, reason, and problem solve in mathematically appropriate and powerful ways.

2.2.2 Teacher related factors

Review of literature suggests that it is difficult to demarcate distinct factors that affect students' mathematics achievements. For instance, as described above, regarding the students' mathematical anxiety as well as developing their reasoning skills can have an impact on the teacher's role is notable. Moreover, Azmidar et al (2017) describe teacher's responsibility in making students interested in mathematics learning, which directly affect students' mathematics achievement. Based on their study authors show how the Concrete-Pictorial-Abstract approach can be used as an alternative to improve students' mathematics interest. Further they point out how this approach helps to change students' attitude of 'mathematics which is commonly labeled as a difficult subject that only contains numbers, formula, and the abstract theorem that were very hard to understand.'

Gafoor & Kurukkan (2015) state that one of the main challenges to mathematics teacher is to develop positive attitudes in students toward learning mathematic. The authors further suggest that teachers should be aware of students" affective beliefs and inter-relations of those in learning mathematics to employ more effective strategies in teaching and to improve students' mathematics learning by reducing their negative beliefs. Further, Barczi (2008) notes that most of the time students are unable to solve problems which are slightly different from the ones they are used to do in the classroom. Teachers should equip their students with a wide range of problem-solving strategies and make sure that students gain enough experience in choosing the most appropriate strategy in each problem situation (Barczi, 2008).

2.2.3 Home environment related Factors

The research literature connecting to home related factors, are directly emphasized the several aspects of parental status. For instance, as reported by Acharya (2017), parents related factors are also one of the important aspect of students' achievements in mathematics. For example, the parental support for children's' mathematics learning at home environment is highlighted in the recent research literature (Jay, Rose, and Simmons, 2018). In this regard the educational backgrounds of parents are important, especially their awareness and interest of the subject matters affects their children to study mathematics (Acharya, 2017). Level of education of parents is also noted as one of the influences for children's mathematics achievement. For instance, as report by Ayoub et al., (2009) and Hanson et al., (2011) in their studies children whose mothers had less than a high school education had lower cognitive skill scores. Similarly, teen mothers and mothers who were illiterate or unemployed were more likely to raise academically underachieving children as compared to those who had a primary or tertiary level of education despite belonging to the same Socio-economic status. Alghazo and Alghazo (2015) state that children education depends on their family background and the parent's

economic status (Lamb and Fullarton, 2015). Related to socio economic status, Daw (2012) suggests that increase in the amount of homework may increase the socio-economic achievement gap in mathematics in secondary school. It can be anticipated that the child may not have enough support from their home environments.

2.2.4 Curriculum related factors

According to the literature the curriculum content matters have a substantial impact on mathematical education. For instance, the 1995 Third International Mathematics and Science Study (TIMSS) data revealed that countries with higher achievement have teachers who teach substantially different content than that of their less accomplished counterparts (Schmidt et al., 2001).

The Singapore Mathematics Curriculum postulates that metacognition is one of the five key competencies for successful problem-solving. Metacognitive behaviors, which involve an awareness of, monitoring, and regulating cognitive resources during problem-solving, support the achievement of 21st-century competencies. For college kids to remember their cognitive processes and effectively monitor and regulate these processes in learning mathematics, teachers need to provide explicit guidance and model these processes in their classrooms. This study focuses on the utilization of inquiries to provide opportunities for college kids to think aloud through an articulation of their problem-solving processes, thus making their thinking visible and creating a greater level of awareness of their cognitive processes. This helps students to monitor their cognitive activities during problem-solving, and to manage their problem-solving processes. It aims to supply teachers with a greater understanding of metacognitive behaviors and build teachers' confidence to develop students to be metacognitive learners (Schmidt et al., 2001).

2.2.5 School, School climate, Principal, and leadership related factors

School, school climate and principal and leadership have always been considered as key factors affecting students' achievement in Mathematics.

Slarter (2010) investigates the differences and similarities in the impact of school leadership on student mathematics achievement in different global regions using TIMSS international data. The findings showed that the variables of teacher professional development and interactions with other teachers at the student level had inconsistent influence on student achievement outcomes across countries. In all but one of the countries in the sample, the proportion of poor students was related to student achievement. In England there were significant differences on several key variables. Further, Boston et al (2017) proposed a framework for considering principals' knowledge and actions to support high-quality instruction in a specific content in mathematics. Using design research, researchers engaged principals in professional development and assessed principals' ability to identify aspects of high-quality mathematical tasks and instruction through pre–post task sort analyses and

classroom video analyses. Significant differences occurred in principals' identification of high-quality mathematics tasks and instruction, students' thinking, and teachers' actions. Subsequent data identified changes in principals' feedback to mathematics teachers; however, this change was not sustained in following years.

Geleta (2017) examines if a relationship exists between organizational school climate and student achievement in Ethiopia secondary schools setting, and to investigate whether the various elements of school climate have independent effects on student achievement. Organizational climate was measured using the School Climate Index (SCI) developed by Tschannen-Moran, Parish and DiPaola and student achievement was measured by students' test scores at the Ethiopia General Education Leaving Certificate Examination (GELCE) in the year 2014/15. The results indicate that school climate has a significant and positive relationship with student achievement in Ethiopia secondary schools, but nonetheless, a weak one. The collegial leadership, teacher professionalism, and academic press were significantly and moderately correlated to students' achievement while the community engagement sub scale was not. The four factors used both for the SCI as predictor variables in the regression model were shown to have a significant relationship with student achievement when viewed as a whole, but they generated more varied results when examined individually. Teachers' professionalism is the most positive predictor of student achievement in Ethiopia secondary schools. Similarly, collegial leadership and academic press are also found to be significant predictor of academic achievement. This study found no independent effect of community engagement on student achievement. The study recommends that school leaders should design school improvement plans that entail the school climate construct, need to find ways of including the community in the life of the school and foster positive relationships with the community. Also, principals need to be mindful that the climate of a school affect achievement and the former can be enhanced to improve results.

Uysal et al (2018) analysed the relationship between Turkish students' mathematics achievement in Programme for International Student Assessment (PISA) 2012 and the instructional climate-related factors in the index of principals' perceptions (learning hindrance, teacher morale and teacher intention). As preliminary analysis procedure, the chi-squared automatic interaction detection analysis was performed with relevant independent variables. Teacher's achievement expectation from students and achievement-oriented behaviours were other significant predictive indicators on PISA mathematics achievement. Based upon these independent variables and standard deviation estimates of PISA mathematics scores, the research developed a theoretical model explaining how students' PISA mathematics achievement is associated with classroom and within school homogeneity through teachers' expectation and achievement-oriented behaviours. Their results showed that the developed model provided a great model-data fit. This model revealed that classroom achievement homogeneity and within school achievement homogeneity were the most important predictors on students' PISA mathematics achievement.

Joo-Ho *et al* (2019) examines how principal support, professional learning communities, collective responsibility, and group – level teacher expectations affect 11^{th} grade student math

achievement in the US and identified that a model of school-level factors affecting students: Principal support positively influenced both professional learning communities and collective responsibility, which in turn, affected student math achievement via group-level teacher expectations. To improve student achievement, the study emphasizes that principals should give more attention to exerting supportive and egalitarian leadership that can contribute to a school's positive climate and lead to changing teachers' instructional behaviors and attitudes, rather than focusing on directive or restrictive leadership and managing behaviors.

Aburizaizah et al (2019) found that wide variability in the extent to which principals display leadership behaviours, based on nationally representative school samples drawn in 2003, 2011, and 2015 for the Trends in International Mathematics and Science Study. Pupil achievement did improve across these cohorts, markedly among girls attending schools in which principals enriched the academic climate and deployed teacher incentives, after considering the social class background of students and the school's instructional resources. Greater availability of resources, including computing tools, improved over the period but did not account for higher achievement in mathematics. Lessons for other nations are discussed, as international donors press decentralized governance, at times ignoring local cultural and institutional contexts.

According to the literature the school climate affects the disparities in students' mathematics achievement. The study conducted by Yuan (2019) explores the effects of school climate on the disparities in students' mathematics achievement, drawing on data from the Programme for International Student Assessment (PISA) 2012 for Shanghai, China. The results of a two-level linear model and quantile regression indicate that three dimensions of school climate (student–teacher relations, disciplinary climate, and students' behaviour) compensate for the effect of family background on students' mathematics performance, and that student–teacher relations and teacher morale can moderate the effect of family background on mathematics achievement for underachieving students and for low-performing schools, respectively. This shows the protective role of school climate in the relationship between family background and students' mathematics performance. School climate has a more significant effect in low- and average-performing schools, and for medium-level students and underachievers, compared with high-performing schools and top students, indicating the potential of school climate in narrowing achievement gaps among schools and students. Furthermore, a negative disciplinary climate is the key factor explaining the under-performance of low-performing schools and underachieving students.

2.3 Mathematics curriculum at the junior secondary level of education in Sri Lanka and the need to incorporate 21st century skills in the teaching learning process.

In this section we briefly review the Sri Lankan mathematics curriculum at the junior secondary level, the need to incorporate 21st century skills in the curriculum and related research findings.

2.3.1 The existing mathematics curriculum at the junior secondary level in Sri Lanka

Many leading international educational authorities regard the Standards for School Mathematics as a global benchmark for designing mathematics curricula (McCaul, 2007). The National Council of Teachers of Mathematics (NCTM) defines standards as 'the Mathematical content and processes that students should know and be able to use as they progress through school.' NCTM sets out five Content Standards which describe explicitly the five strands of content that students should learn, and five Process Standards highlighting the ways of acquiring and applying content knowledge.

Athurupane et al. (2011), observe that Sri Lankan content standards and process standards in the current mathematics curriculum are aligned with international standards. International trends in Mathematics education focuses on developing individuals with the reasoning abilities and communication skills that are required to solve everyday problems, by integrating the traditional content of Mathematics to understand the real world.

Gunewardena (2014) analyzes the suitability of the new curriculum as a competency-based curriculum and examined whether it has achieved its objectives. Gunawardene concludes that the new curriculum was better in elaborating the subject content and teaching methods. However, in a broader sense, it has not fulfilled its objectives as a competency-based curriculum where the competency-based teaching and learning approaches were superficially introduced. Furthermore, the curriculum documents did not accurately reflect their intended objectives.

Above review suggests that although the existing mathematics curriculum is guided by standards for school mathematics they are not adequately defined and addressed in the curriculum materials to facilitate the achievement of competencies by the students.

2.3.2 The need to incorporate 21st century skills in the mathematics curriculum and teaching learning process

The world is changing at an unprecedented pace, so much so that jobs that existed for decades are disappearing by the day. This implies that educators need to take responsibility in preparing students to take up challenges of the future and infusing skills that they need to succeed in the employment markets that they will be entering. These are collectively referred to as 21st century skills (Mugabi, 2019). Incorporating 21st century skills in the classroom is vital for equipping students with the adaptability skills that they need to succeed in today's fast-paced world. These skills help students to be more cooperative, bring out their curiosity, increase their motivation to learn more, and to become lifelong learners (Mugabi, 2019). Also, skills that play a key role in teaching students to seek deep understanding of knowledge and facilitating the transfer of knowledge to new environments gain more importance (Bialik & Fadel, 2015). The report of (Organization for Economic Cooperation and Development (OECD, 2017) suggests that literacy, problem-solving skills, information and communications skills, management, STEM

(Science, Technology, Engineering, and Mathematics) skills, and self-organization and learning readiness skills are in high demand in industries where digitalization is higher.

According to Turhan and Demirci (2021), in the context of understanding, teaching, questioning, and improving 21st-century skills, many studies have been conducted on the use and positive effects of contemporary approaches. For instance, Setyarto et. al., (2020) states that project-based learning (PBL) can be an alternative learning model that supports the improvement of 21st-century skills. Students determine their own collaborative learning processes, conduct research, make creative projects, and reflect knowledge they have. One of the project-based learning models is the STEAM learning model (Science, Technology, Art, and Mathematics) in the form of mathematical engineering techniques integrated into the learning curriculum that can be used as an extracurricular activity in the form of STEAM clubs to strengthen the skills of students in scientific disciplines, craft art, and mathematics. It has been proposed that "students cannot fully comprehend STEM-related concepts without engaging in problem-based learning experiences" (Asunda & Mativo, 2016, p. 9). Therefore, the environment in which STEM will be most effective is in a PBL classroom. Lapek (2018) investigated with the help of Problem Based Learning (PBL), programs like STEM education, and Technology and Engineering Education (TEE), more students are being given opportunities to develop 21st century skills like technological literacy, critical thinking, problem-solving, creativity, collaboration, and communication. By providing opportunities for authentic learning activities and content integration, PBL, STEM, and TEE are preparing students to survive and thrive in a technologically driven world. Studies have shown that when "low ability" students are "immersed in a PBL environment" they show 446% increased use of critical thinking and collaboration skills; "high ability" students show an increase of 76% of these same skills (Mosier et al., 2016, p. 3). Clearly, PBL is suited for all learners – high and low achievers alike – to improve their 21st century skills. As a result, PBL helps to prepare all students for the rapidly changing world regardless of their cognitive abilities.

Further, Li et al., (2013) explored that through digital game building and design demands teachers' deep understanding of the related technology and the appropriate pedagogy may be helpful in students acquire 21st -century skills. They conclude that immersing preservice teachers in the experience of designing and building their own games provides an effective opportunity to develop such technological and pedagogical expertise.

Further, Turhan and Demirci, (2021) stated that to infuse students with 21st century skills, it is necessary to bring together the elements of an effective teacher-education model for meeting the needs of the 21st century. Teacher education programmes must ensure that teachers to become sensitive to all the problems around them, who produce solutions, and who have a stance (Tutkun & Aksoyalp, 2010). Most pre-service teachers need professional development to structure their teaching in 21st-century skills (Bedir, 2019). For this purpose, it is crucial to train pre-service teachers in a conducive educational environment for developing 21st-century learner skills (Göksün & Kurt, 2017; Jacobson-Lundeberg, 2016).

Literature reviewed in this section highlight the need to use student active methods of teaching in developing 21st century skills among mathematics learners and improving professional development programmes for teachers.

Chapter 3: Methodology

3.0 Introduction

This chapter describes the methodology adopted in the phase 1 of the CAR. A survey research design was employed in the phase 1 and the chapter elaborates in detail the research design, the sampling strategy and data collection instruments used, and how the data were collected.

3.1 Research design

In phase 1 of the study a descriptive survey research approach was employed with multiple methods of data collection. The design of the study is summarized below in Table 3. 1.

Table 3. 1 Research design

Relevant Research question(s)	Data needed	Data collection Instruments
1. What is the existing situation of Mathematics teaching and learning at the junior secondary level in the selected province? 2. What are the key factors affecting teaching, learning and achievements in Mathematics in the province? 3. What interventions are necessary at distinct levels of the education system to improve teaching and learning mathematics and instilling 21st century competences among students in the junior secondary level?	• Students Marks at the end of first term • Characteristics of students, • Views of students on teaching and learning mathematics • Beliefs, attitudes, and views on learning mathematics • Characteristics of Mathematics teachers, their beliefs, attitudes and views on teaching math, students, and their parents • Views of principals on teaching and learning of Mathematics, Students achievements etc. • All the above data • Literature on instilling 21st century skills among mathematics learners	• Documents- Mark sheets prepared by Math teachers in the first term test. 2019 • Questionnaire for students • Questionnaire for teachers • Interview schedules for principals, teachers, and students • Observation of classroom teaching practices

3.2 Sampling

Multistage sampling method is applied for selecting schools, classrooms, teachers, and students for this study. In stage one a stratified random sample of fifty schools were selected based on grade type of schools (Type 1AB, 1C and Type 2 schools) and the ethnic type (Sinhala, Tamil, and Muslim Schools). At stage 2 one classroom and one mathematics teacher from Grade 7 classes in each school were selected randomly for classroom observation and for administering the teacher questionnaire and conducting interviews. In the final stage a cluster sample of students (all students in the classroom) were selected for administering the student questionnaire.

SELECTING THE SCHOOL SAMPLE

Table 3. 2 Number of schools in each district according to the school type

DISTRICT	Type 1AB	Type 1C	Type 2	Total
Kandy	60	163	208	**431**
Mathale	20	64	100	**184**
Nuwara Eliya	34	92	146	**272**
Total	**114**	**319**	**454**	**887**

Population of Schools: 887

Selected sample of school: 50 (Using stratified sampling)

Table 3. 3 Population

School Type	Sinhala	Tamil	Muslim	Total
Type 1AB	86	16	12	114
Type 1C	215	66	38	319
Type 2	288	130	36	454
Total	**589**	**212**	**86**	**887**

Selected the sample using Ethnicity and Grade type of the school:

Table 3. 4 Sample

School Type	Sinhala	Tamil	Muslim	Sample size
Type 1AB	4	1	1	06
Type 1C	12	4	2	18
Type 2	17	7	2	26
Sample size	**33**	**12**	**05**	**50**

Random number generation method is used to select the fifty schools from the school list given by provincial education office after grouping them according to the Grade type and Ethnic type. Find the cumulative frequency of grade 7 students and selected the school which related to the generated random number.

Student population

Table 3. 5 Number of Grade 7 students in each school type with respect to ethnicity

School Type	Sinhala	Tamil	Muslim	Total
Type 1AB	13571	2110	1752	**17,433**
Type 1C	10204	4888	2056	**17,148**
Type 2	4397	3917	638	**8,952**
Total	**28,172**	**10,915**	**4,446**	**43,533**

Total Grade 7 Student Population = 43,533

Student sample

Table 3. 6 Student's population in Selected 50 Schools:

School Type	Sinhala	Tamil	Muslim	Total
Type 1AB	397	183	150	**730**
Type 1C	627	569	271	**1467**
Type 2	547	320	49	**916**
Total	**1571**	**1071**	**470**	**3113**

One class each from each of the fifty schools was selected and the total number of students in that class was included in the student sample. When there were parallel classes only one class was selected randomly.

Table 3. 7 Selected student's sample

School Type	Sinhala	Tamil	Muslim	Total
Type 1AB	170	60	50	**280**
Type 1C	354	180	90	**624**
Type 2	361	200	49	**610**
Total	**885**	**440**	**189**	**1514**

Selected student sample = 1514

Table 3. 8 Students sample after data cleaning:

School Type	Sinhala	Tamil	Muslim	Total
Type 1AB	165	60	47	**272**
Type 1C	341	157	86	**584**
Type 2	307	161	47	**515**
Total	**813**	**378**	**180**	**1371**

Table 3. 9 Description of the student sample

District	Total	Gender			School type				Ethnicity					Age					
		Female	Male	Missing	1AB	1C	2	Missing	Sinhala	Tamil	Muslim	Other	Missing	10	11	12	13	14	Missing
Kandy	565	295	267	03	50	132	383	00	346	111	101	4	03	2	29	389	135	7	3
Mathale	232	131	101	00	0	148	84	00	215	16	1	0	00	0	18	200	14	0	0
N-Eliya	574	285	287	02	115	61	398	00	223	269	74	5	03	1	21	279	263	6	4
Total	**1371**	**711**	**655**	**05**	**165**	**341**	**865**	**00**	**784**	**396**	**176**	**9**	**06**	**3**	**68**	**868**	**412**	**13**	**6**

Composition of the sample

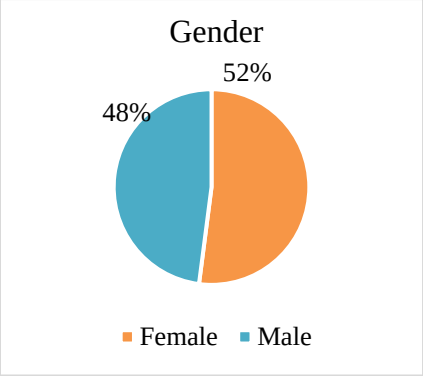

Figure 3. 1 Pie chart of Students sample by Gender

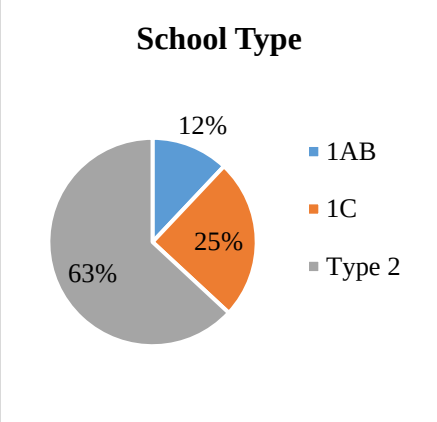

Figure 3. 2 Pie chart of Students sample by School Type

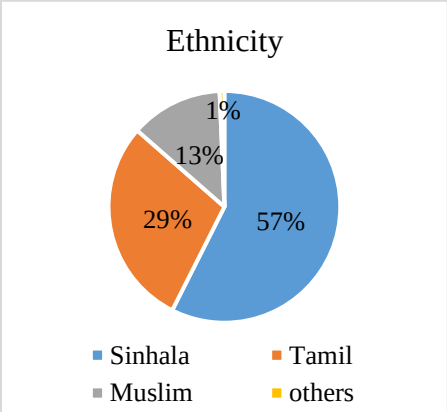

Figure 3. 3 Pie chart of Students sample by Ethnicity

According to the Figure 3.1, 52% of students are females while 48% students are being males. As shown in the Figure 3.2, 63% of students are from type 2 schools, 25% students from 1C schools and 12% of students from 1AB schools. Figure 3.3 represents the students' sample by

Ethnicity. 57% of students are from Sinhala schools, 29% percent of students are from Tamil schools, 13% of students are from Muslim schools and 1% of students are from other schools.

3.3 Instruments used for data collection

Teacher questionnaire

A questionnaire consisted of questions adapted from Mathematics Teacher Questionnaire of the 2000 National survey of Science and Mathematics Education (Weiss et al, 2001) and Mathematics teacher questionnaire of International Association for the Evaluation of Educational Achievement (IEA) Trends in International Mathematics and Science Study (TIMSS)(Mullis et al, 2012) was used to gather information on the mathematics teachers demographic data and their views on a range of factors affecting teaching and learning in their classrooms.

Student questionnaire

A questionnaire consisted of questions adapted from Mathematics Students' questionnaire of IEA Trends in International Mathematics and Science study (Mullis et al, 2012) was used to gather information of the Grade 7 students' demographic data and their views on a range of factors affecting teaching and learning in their classrooms.

Observation Schedules

A structured observation schedule and a semi-structured observation schedule was used for recording classroom practices of teachers.

For the current study we have selected the Quality of Teaching (QoT) framework developed by school inspection teams of five European countries. The instrument initially developed specifically focusing on the teaching of mathematics in primary schools. Subsequently it has been used in other curriculum areas and secondary schools within UK (Ingram et al , 2018). The QoT is a value based framework with high inference codes which require the observers to balance the strengths and weaknesses of different aspects of the classroom practice being observed (Ingram et al, 2018). The framework consists of six quality standards which are related to a number of indicators and a number of good practices related to each indicator. The six standards are: *efficient classroom management* (4 indicators with 10 good practices); *safe and stimulating learning climate* (7 indicators with 20 good practices); *clear instruction* (7 indicators with 23 good practices) ;*adaption of teaching* (2 indicators and 6 good practices); *Teaching learning strategies* (3 indicators and 7 good practices) and *involvement of pupils* (one indicator and 3 good practices). The observers have to score each indicator on a 1-4 scale depending on the balance of strengths and weaknesses determined on the basis of the number of good practices observed or not observed in the particular classroom. For each good practice observed in a class is marked as 1 and each good practice not observed is marked as 0. Following key is used to rate each indicator:

1= Predominently weak

2= more weaknesses than strengths

3= more strengths than weaknesses

4= predominantly strong

3.4 Enumerator training

The classroom lessons of mathematics teachers were observed by trained observers using the above mentioned QoT framework adapted for the Sri Lankan context. Twenty-five teachers who had recently completed Master of Education or Master of Science Education programmes of the University of Peradeniya and five other senior teachers of mathematics from secondary schools were selected as observers. One day training workshop conducted for the observers. First, they were given a copy of the observation instrument after a brief introduction and allowed to study it for a while and make comments and ask any clarification questions about it. After the discussion they were allowed to observe a video recorded mathematics lesson while individually recording observed teacher behaviors and students' behaviours in a tabular format which had three columns titled teacher behavior, student behavior and remarks. In the remarks column they were asked to record relevant any other incidents happened in the classroom and their thoughts about what is happening in the classroom. Immediately after the observation they were allowed adequate time to rate the QoT schedule. The research team consisting of four academics from the university department of education also observed the lesson and rated the schedule individually. A detailed discussion held afterwards on each of the good practice examples given in the framework and the disparities in rating teacher indicators to arrive at consensus to decide a common set of ratings. This process helped the observers to get familiar with the observation framework, improve conceptual understanding of the standards and indicators as well as the rating procedure.

During data collection each observer collected data from one to three schools. A descriptive record of each lesson written according to the given additional format and the completed observation schedules were collected for each of the fifty classrooms. In addition to classroom observations, the enumerators had to administer the teacher questionnaire and students' questionnaires as well as to conduct brief interviews with the teacher that they observed, the principal and two selected students.

3.5 Administration of questionnaires and observation schedules

Enumerators administered the questionnaires in person in each school and observed one lesson of one mathematics teacher who teaches mathematics at Grade 7. Prior to administering the questionnaires, observations and interview the instruments were pilot tested in three schools by selected research assistants.

Piloting

The instruments were translated into Sinhala and Tamil languages and piloted in six classrooms. The pilot study of the observation schedule revealed that since it was a high inference value based instrument and it was difficult to score all the indicators while observing the classroom. Keeping a detail record of teacher and students behaviours observed, relevant other observations and thoughts of the observer during the observation and subsequent scoring found to be more practical. Hence a semistructured observation schedule was designed and used for data collection during the classroom observation as described in sectin 3.4. Similarly the teacher questionnaire was piloted with a group of mathematics teachers following the PGDE programme and made necessary amendments based on the feedback of teachers. The student questionnaire was piloted in the same classrooms where the piloting of observation schedule took place.

Reliability measures of the questionnaires and observation schedule

Table 3. 10 Reliability of Students Questionnaire

Variable	Cronbach Alpha Value
Co-Curricular Activity Participation	0.009
Mathematics related activities	0.745
Availability of Electronic Devices	0.778
Usage of Electronic Devices	0.657
Use of Computer for learning	0.763
Use of Internet for learning	0.885
Attitude towards School	0.581
Peer Relationship	0.812
Attitude towards mathematics learning	0.899
Evaluation of the teacher	0.519
Mathematics Self Efficacy	0.647
Attitude towards mathematics	0.524

Table 3. 11 Reliability of Teachers Questionnaire

Variable Name	Cronbach Alpha Value
Academic climate in the school	0.792
Parental expectations and support	0.830

Safety and behaviour	0.785
Physical facilities for teaching	-0.778
Professional interactions with other teachers	0.905
Job satisfaction	1.000
Teacher workload and working conditions	0.044
Identification of curriculum objectives	-0.192
Preparedness for teaching (Numbers)	0.872
Preparedness for teaching (Measurements)	0.851
Preparedness for teaching (Algebra)	0.972
Preparedness for teaching (Geometry)	-0.048
Preparedness for teaching (Statistics)	0.816
Preparedness for teaching (Sets and Probability)	0.517
Classroom teaching practices	-0.042
Student related limitations affecting teaching	0.767
Teachers' self-efficacy	0.874
Homework	1.000
Assessments	0.336
In-service teaching	1.000

Table 3. 12 Reliability of Observation Schedule

Variable	Cronbach Alpha Value
Efficient Classroom management	0.675
Safe Stimulating Learning Climate	0.783
Clear Instructions	0.722
Adaption of Teaching	0.693
Teaching And Learning Strategies	0.643

3.6 Data analysis

Quantitative data were analysed using SPSS ver22. And the qualitative data were analysed using constant comparative method and thematic analysis.

3.7 Ethical issues

The research team obtained due permission from the provincial director of education of the Central Province to conduct the survey study in the selected fifty schools. Consent of the teachers and principals were obtained prior to the interviews, classroom observations and questionnaire administration.

Chapter 4: Analysis of Data

4.0 Introduction

This chapter presents the analysis of data collected in the survey research study conducted in the Phase 1. The data are analysed in relation to the following three specific questions addressed in the Phase 1.

1. What is the existing situation of Mathematics education in the junior secondary level in the selected province?
2. What are the key factors affecting teaching, learning and achievements in Mathematics in the provincial and classroom levels?
3. What interventions are necessary at distinct levels of the education system to improve teaching and learning mathematics and instilling 21st century competences among students in the junior secondary level?

4.1 What is the existing situation of Mathematics education at the junior secondary level in the selected province?

Existing situation of Mathematics achievements at the junior secondary level of the Central province was analysed using the data collected from Grade 7 classrooms of a multi staged cluster sample of fifty schools. Student achievement data were based on the first term test conducted by the Provincial Department of Education (PDE) of the Central province in 2019. The actual sample of teachers and students participated in the survey and the classrooms observed and Mark sheets collected are given in Table 4.1

Table 4. 1 Actual sample of students, teachers and classrooms included in the survey

No. of students Answered the questionnaire	No. of teachers Answered the questionnaire	No. of classrooms observed	No. of Mark sheets collected
1371	50	50	50

4.1.1 Mathematics achievements according to the Grade type of school.

Table 4. 2 Mean scores and percentile values of Mathematics achievements by the type of school

School Sample	Mean	Standard Deviation	Standard Error of Mean	Minimum	Maximum	P25= Q1	P50= Q2	P75= Q3	Skew ness
1AB	29.55	21.280	2.207	2	91	11.50	26.00	40.00	0.996
1C	33.87	23.910	1.130	0	99	14.00	28.00	51.75	0.625
Type 2	26.29	19.892	0.763	0	90	10.00	22.00	38.00	0.924
Total	29.32	21.831	0.625	0	99	11.00	24.00	43.00	0.843

One-way ANOVA results indicated a significant difference between achievement of students in distinct types of schools; $F(2,1218) = 16.680$, $p = 0.000 < 0.05$.

The overall mean score 29.32 is well below the mean score of Grade 8 Mathematics (48.89) of the National assessment by NEREC (2016). According to the Table 4.2 highest mean score is in Type 1C schools.

Figure 4.1 further indicates the distribution of cumulative frequency percentage for the total sample. (n= 50). According to the figure 4.1, 72.89 percent students scored below 40 marks and 22.2 percent scored 0-10 marks. Less than 3 percent of students scored more than 80 marks. Table 4.2 and Figure 4.1 clearly indicates that mathematics achievements need improvement.

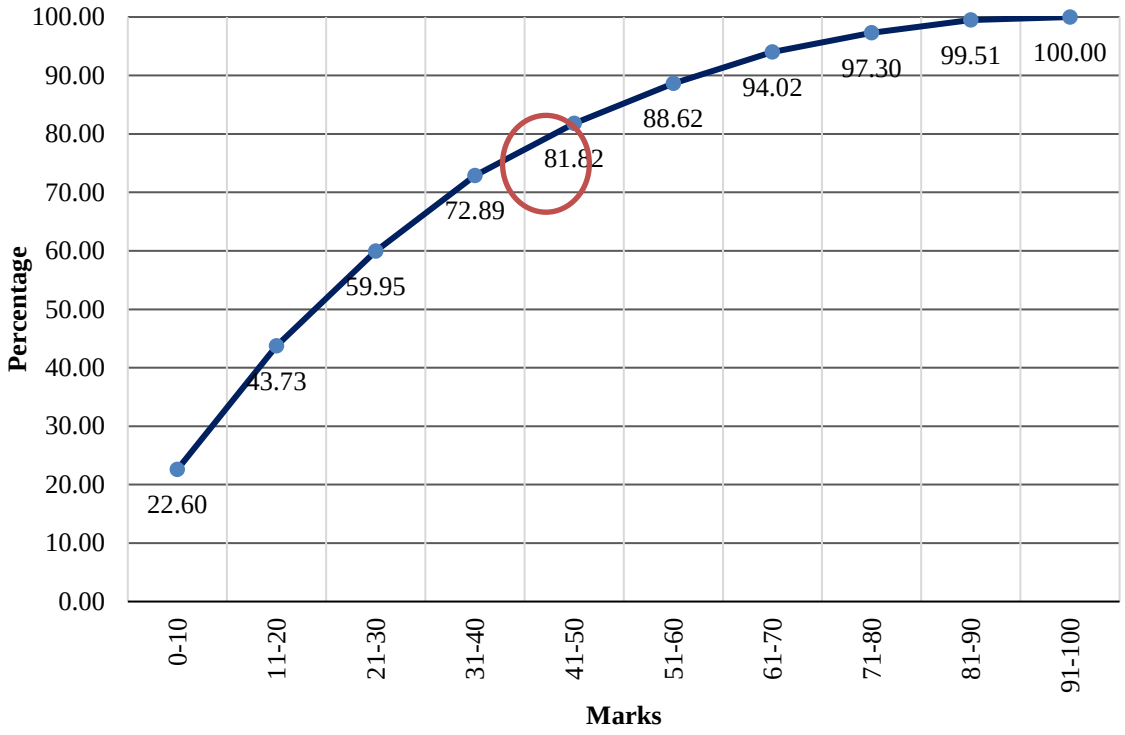

Figure 4. 1 Cummulative Frequency Percentage

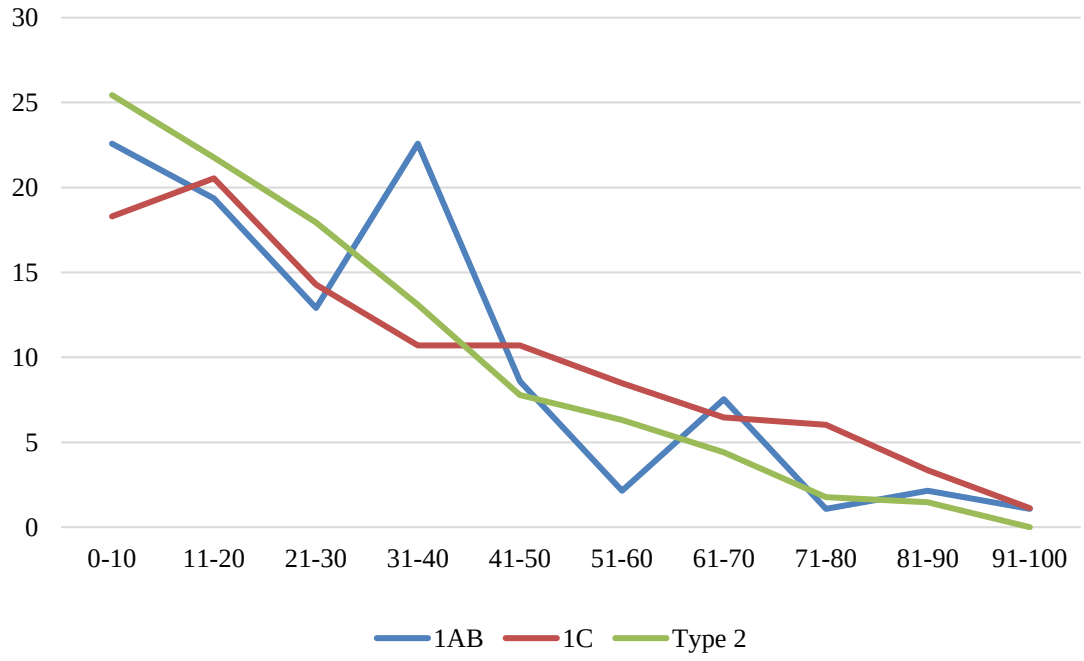

Figure 4. 2 School achievement by the Grade type of school

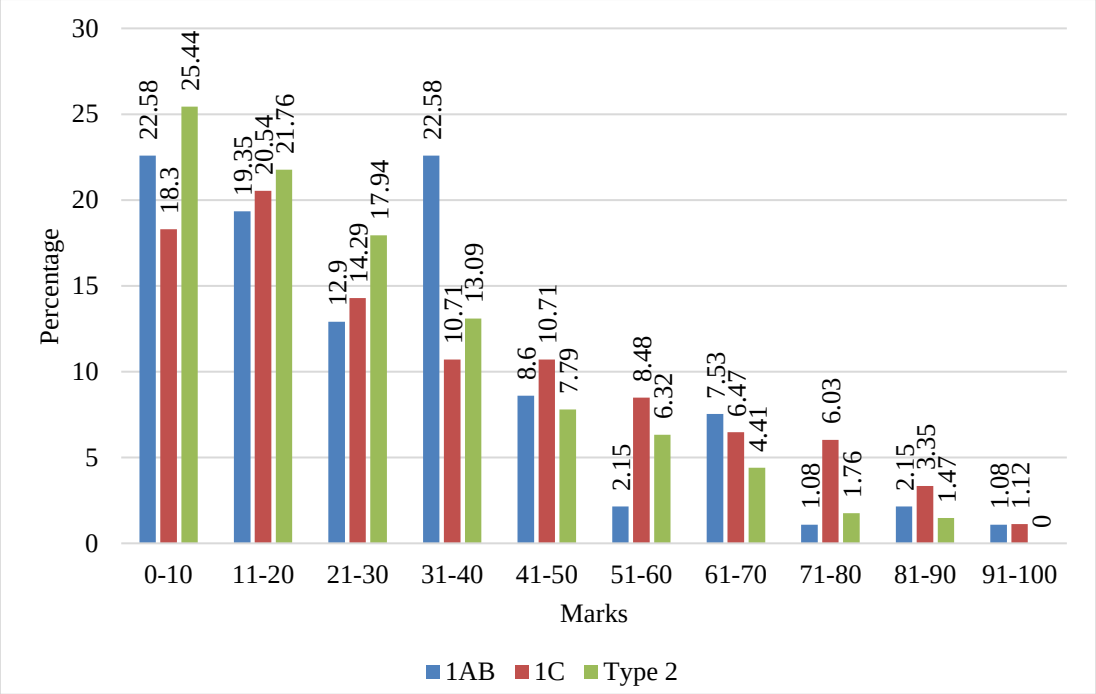

Figure 4. 3 Students' achievement by the grade type of school

One-way ANOVA results demonstrated a significant difference between grade type of the school on achievement of students; F (2,1218) = 16.680, p = 0.000 < 0.05.

According to the Figures 4.2 and Figure 4.3, type 1C shows better achievements than type 1 AB and Type 2 schools

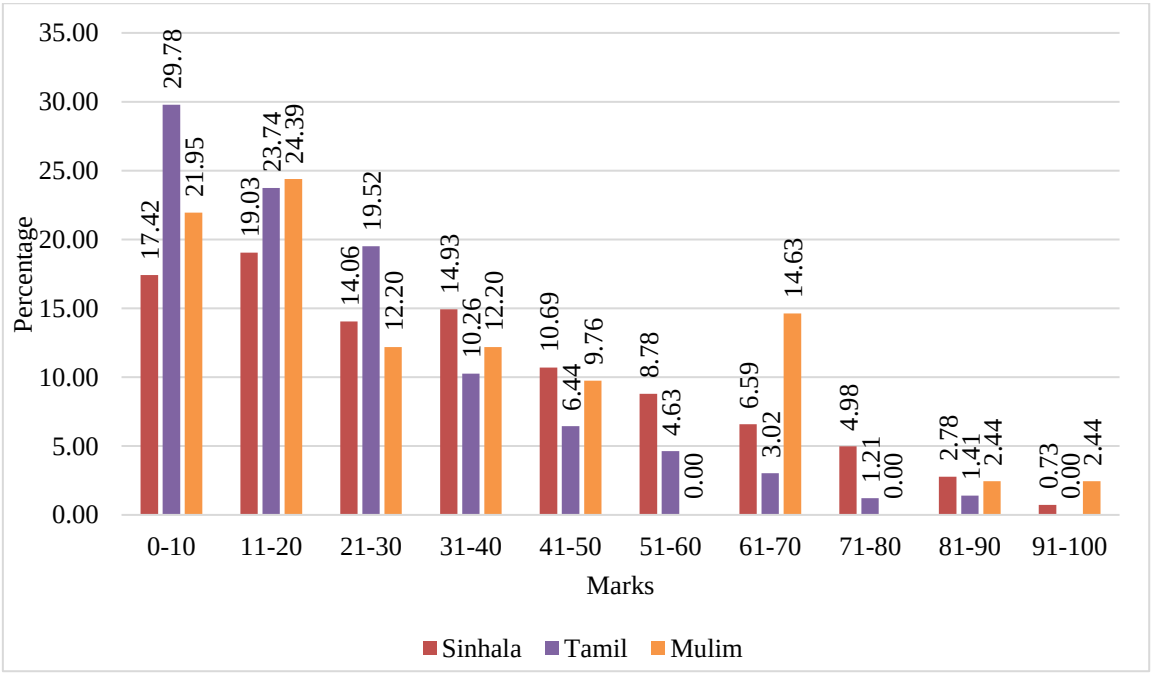

Figure 4. 4 Students achievement by Ethnic type

According to the Figure 4.4, the students got more than 70 marks in the Sinhala schools is higher than the Muslim schools and Tamil schools in the selected sample of schools. Only 1.41% of total students in the Tamil schools scored higher than 70 marks for mathematics.

4.2 Factors Affecting Students Achievements

4.2.1 Student related factors from the perspective of the students

4.2.1.1 Students' Absenteeism

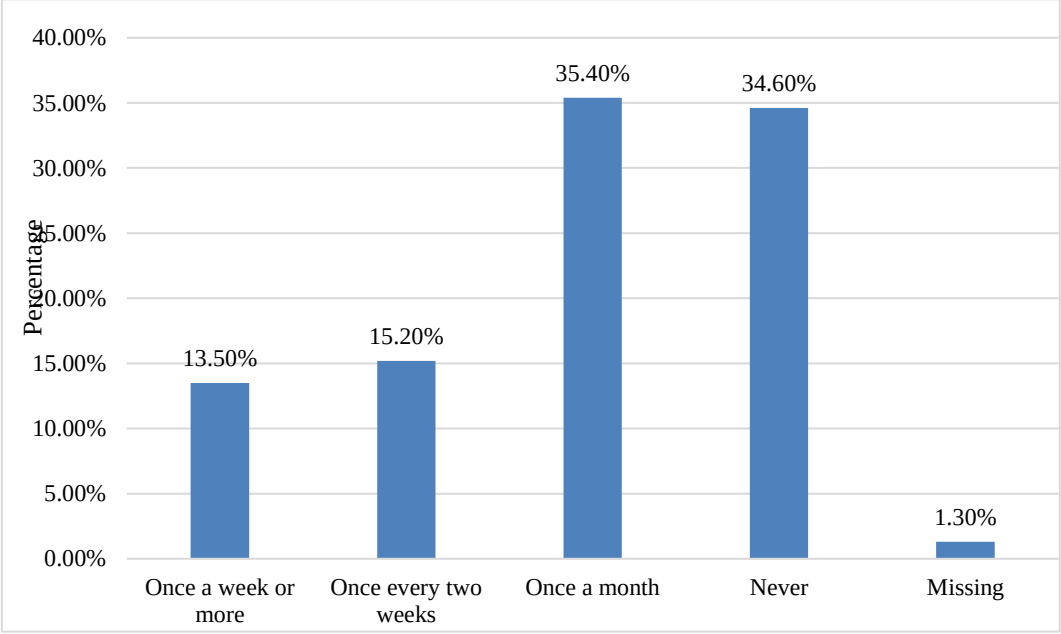

Figure 4. 5 Bar chart of Students' Absenteeism

About 70% of the students attend the school regularly (Without getting absent for more than one day per month) while about 35% of the students get never absent.

Hypothesis Testing

Table 4. 3 Hypothesis testing

	P-value	Decision
Gender	0.732	Not Significant
Ethnicity	0.003	Significant
School Type	0.000	Significant

There is no significant difference between students' attendance by gender. However, there are significance differences in students' attendance by ethnic (p= 0.003) and school (p= 0.000) types.

4.2.1.2 Academic Aspiration

Table 4. 4 Academic Aspiration of students

Academic Aspiration	Frequency
Less than ordinary level	1.4%
O/L	3.0%
A/L	9.2%
Diploma	6.4%
Degree	19.7%
Postgraduate Degree	60.3%

Students reported elevated level of aspirations. 80% of students reported that they expect to achieve 1st degree or postgraduate degree level qualifications. 4.4 % of students reported that they want to achieve up to G.C.E. Ordinary Level qualifications.

Chi Squared Test:

Table 4. 5 Chi-squared Test

	Gender	Ethnicity	School Type
Academic Aspirations	Significant	Significant	Significant

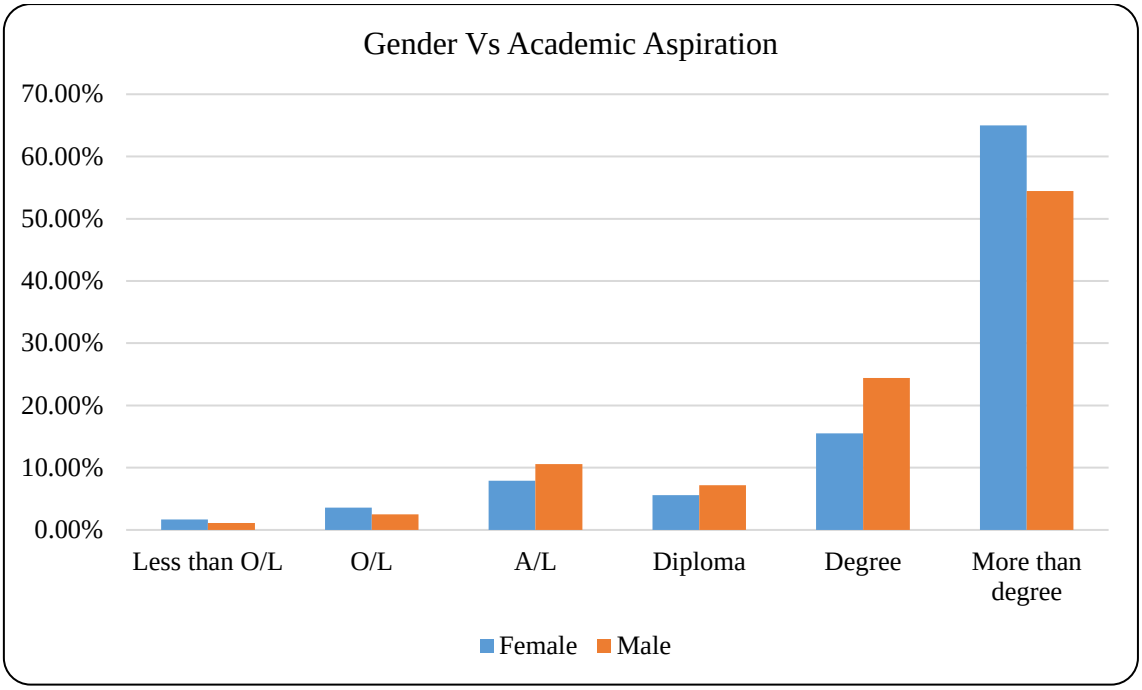

Figure 4. 6 Academic Aspirations by Gender

According to Figure 4.6 girls recorded higher aspirations than the boys.

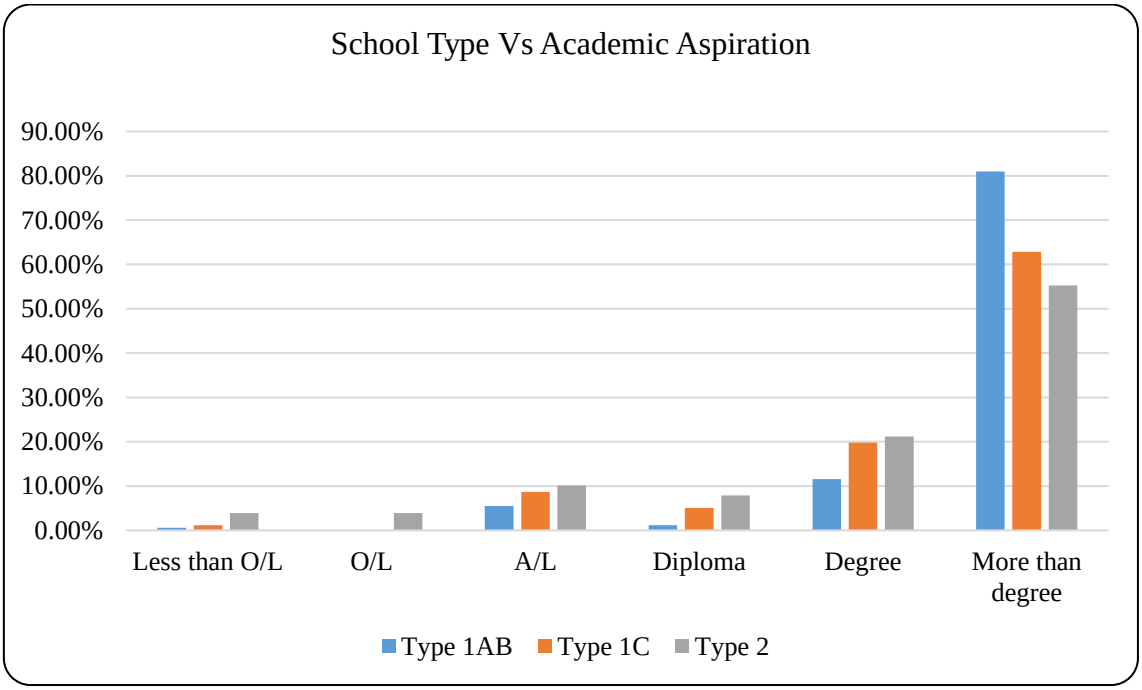

Figure 4. 7 Academic Aspirations of students by school types

According to above Figure 4. 7 Students in Type 1AB schools recorded higher aspirations than students in Type 1C and 2 schools.

4.2.1.3 Peer Relationship

Table 4. 6 Students Responses in relation to Peer Relationships

Variable	Agree	Disagree	Missing
Made fun of me or called me names	52.00%	46.60%	1.4%
Left me out of their games or activities	27.20%	71.30%	1.6%
Spread lies about me	33.50%	65.30%	1.2%
Stole something from me	31.40%	66.30%	2.3%
Hit or hurt me (e.g., shoving, hitting, kicking)	26.70%	70.40%	3.0%
Made me do things I did not want to do	24.60%	72.70%	2.7%
Shared embarrassing information about me	21.00%	74.40%	4.6%
Posted embarrassing things about me online	9.40%	87.80%	2.8%
Threatened me	20.30%	78.00%	1.7%

According to the Table 4. 6, about 65- 72 % of students indicated that they have good relationships with the peers. However about 52% indicated that name calling is quite prevalent among their peers. About 28 – 35% of students indicated that negative behaviours such as social isolation of peers, spreading lies, stealing from peers, hitting, or hurting peers, intimidation, sharing embarrassing information and threatening were prevalent. 9.40% of students reported that their peers embarrassed them online.

Student's beliefs of the importance of Mathematics

Table 4. 7 Students' beliefs of the importance of Mathematics

Variable	Agree	Disagree	Missing
I think learning mathematics will help me in my daily life	93.90%	5.20%	0.90%
I need mathematics to learn other school subjects	88.30%	10.70%	0.90%
I need to do well in mathematics to get into the college or university of my choice	93.10%	5.70%	1.20%
I need to do well in mathematics to get the job I want	88.20%	10.80%	1.00%
I would like a job that involves using mathematics	85.90%	13.00%	1.20%
It is important to learn about mathematics to get ahead in the world	93.30%	5.50%	1.20%
Learning mathematics will give me more job opportunities when I am an adult	73.80%	4.40%	21.70%
My parents think that it is important that I do well in mathematics	95.00%	3.70%	1.30%
It is important to do well in mathematics	88.60%	3.80%	7.70%

Students considered Mathematics as an important subject for learning because that they believe Mathematics will help: their daily life; to learn other school subjects; to enter higher education; to get the jobs that they want; to get ahead in the world etc.

Ninety-five percent of the students reported that their parents expect that it is important to do well in Mathematics. Eighty-eight percent of students believe that they need to do well in Mathematics to get a job that they want to do. 73.8 % of students believe that learning Mathematics will give them more job opportunities in their future.

4.2.1.4 Students Attitude towards Mathematics Learning

Table 4. 8 Students Attitude towards Mathematics Learning

Variable	Agree	Disagree	Missing
I enjoy learning mathematics	91.20%	7.90%	0.9%
I wish I did not have to study mathematics	26.90%	71.80%	1.3%
Mathematics is boring	33.10%	64.50%	2.3%
I learn many interesting things in mathematics	87.30%	10.60%	2.1%
I like mathematics	92.40%	6.70%	1.0%
I like any schoolwork that involves numbers	88.60%	9.90%	1.5%
I like to solve mathematics problems	89.20%	9.90%	0.9%
I look forward to mathematics class	87.60%	10.70%	1.7%
Mathematics is one of my favourite subjects	88.00%	10.80%	1.2%

Students indicated that they like to learn Mathematics and Mathematics related activities and 91.2% reported that they enjoy learning Mathematics. However, 26-33% reported that Mathematics is boring, and they wish that they did not have to study Mathematics. It is not clear why do about 18-25% of the students responded positively to the contrasting statements that indicated positive and negative attitudes.

4.2.1.5 Mathematics Self-efficacy

Table 4. 9 Mathematics Self-efficacy

Variable	Agree	Disagree	Missing
I usually do well in mathematic	92.50%	6.70%	0.8%
Mathematics is more difficult for me than for many of my classmates	47.10%	51.50%	1.5%
Mathematics is not one of my strengths	43.50%	55.20%	1.3%
I learn things quickly in mathematics	84.00%	14.50%	1.6%
Mathematics makes me nervous	35.60%	62.40%	2.0%
I am good at working out difficult mathematics problems	77.60%	19.00%	3.5%
My teacher tells me I am good at mathematics	75.90%	22.40%	1.7%
Mathematics is harder for me than any other subject	40.90%	57.30%	1.8%
Mathematics makes me confused	35.30%	63.40%	1.2%

Although 92.5% of students indicated that they are confident and doing well in Mathematics. However, 35.6-43.5% of students at the same time reported that Mathematics is not one of their strengths, Mathematics makes them nervous, and Mathematics is harder for them than any other subject. Thirty-five percent indicated that Mathematics makes them confused.

4.2.1.6 Participation in External Tuition class and Reason for Participation

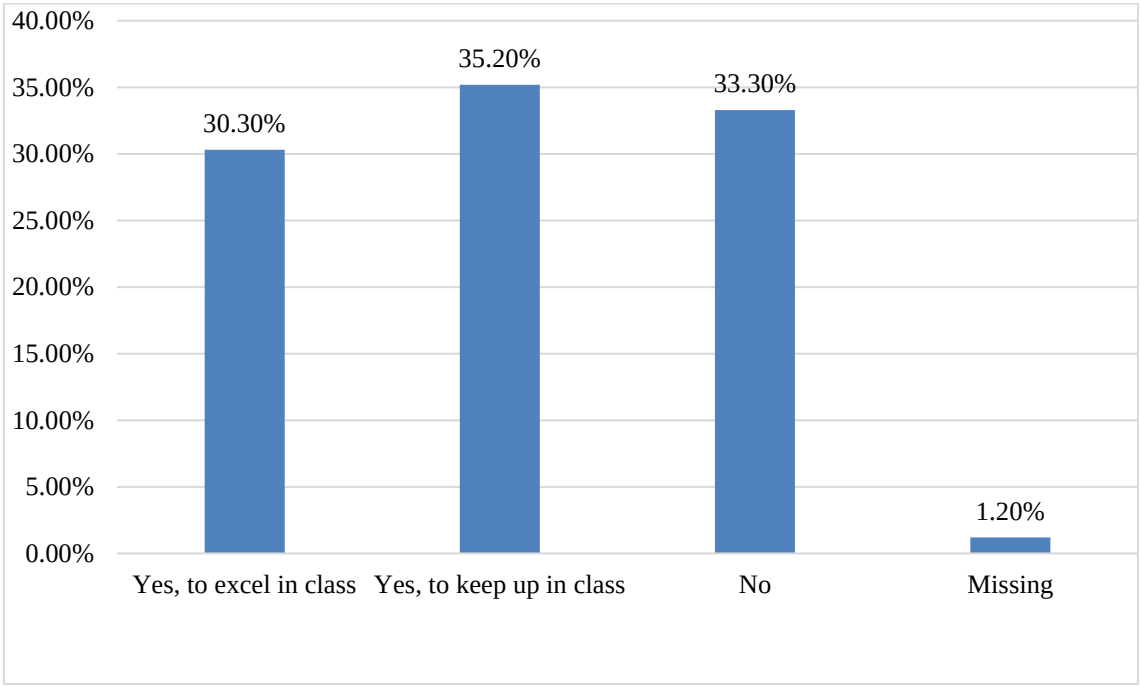

Figure 4. 8 Bar chart of Participation in External Tuition class and Reason for Participation

Sixty-five percent of the students participate in paid tuition classes out of which 30% indicated that they participate in tuition classes to become an expert in class and 35.2% their participation to better learn in class.

Hypothesis Testing

Table 4. 10 Hypothesis Testing

	P-value	Decision
Gender	0.231	Do not reject H_0
Ethnicity	0.000	Reject H_0
School Type	0.000	Reject H_0

There was a significance difference in student's participation in tuitions classes by ethnicity (p= 0.000) and school type (p=0.000). There was no difference between participating tuition classes by gender (p=0.231).

4.2.2 Teacher Related factors from the perspective of the students

4.2.2.1 Evaluation of the teacher's teaching and interaction with the student

Table 4. 11 Evaluation of the teacher's teaching and interaction with the student

Variable	Agree	Disagree	Missing
I know what my teacher expects me to do	84.80%	14.20%	1.1%
My teacher is easy to understand	91.20%	8.00%	0.8%
I am interested in what my teacher says	92.30%	6.80%	0.9%
My teacher gives me interesting things to do	87.50%	10.70%	1.7%
My teacher has clear answers to my questions	93.00%	6.20%	0.9%
My teacher is good at explaining mathematics	93.00%	6.10%	0.9%
My teacher lets me show what I have learned	92.70%	6.20%	1.2%
My teacher does a variety of things to help us learn	89.80%	8.60%	1.6%
My teacher tells me how to do better when I make a mistake	92.90%	6.40%	0.7%
My teacher listens to what I have to say	91.20%	8.10%	0.7%

Majority of students (84% to 94%) evaluate that teacher's teaching behaviours and interaction with the students positively.

4.2.2.2 Mathematics Homework and Assignments

Table 4. 12 Mathematics Homework and Assignments

	Everyday	3 or 4 times a week	1 or 2 times a week	Less than once a week	Never	Missing
Percentage	62.4%	24.0%	9.8%	2.5%	0.4%	0.9%

About 97% of students agree that teacher's give homework and assignments on a regular basis where 62.4% indicates that this is happening every day.

Hypothesis Testing

Table 4. 13 Hypothesis Testing

	P-value	Decision
Gender	0.882	Do not reject H_0
Ethnicity	0.081	Do not reject H_0
School Type	0.000	Reject H_0

4.2.3 School Related factors from the perspective of the students

4.2.3.1 Attitudes towards school and school climate

Table 4. 14 Attitudes towards school and school climate

Variable	Agree	Disagree	Missing
I like being in school	96.30%	3.20%	0.7%
I feel safe when I am at school	93.60%	5.10%	1.2%
I feel like I belong at this school	83.80%	14.60%	1.6%
I like to see my classmates at school	93.90%	4.70%	1.4%
Teachers at my school are fair to me	94.00%	4.70%	1.2%
I am proud to go to this school	93.70%	4.90%	1.4%
I learn a lot in school	95.50%	3.30%	1.2%

Students indicated positive attitudes towards school and school climate. 83.8% - 96.3% agree to all seven statements under this category. About 14.6% students disagreed that they felt belonging to their school.

4.2.3.2 Co-curricular Activity Participation outside of school

Table 4. 15 Co-curricular Activity Participation outside of school

	Variables	Yes	No	Missing
04a	Do you play outside of school	54.3%	44.2%	1.5%
04b	Do you often engage in dancing/music/ art outside of school	46.6%	51.3%	2.0%
04c	Are you studying something in a class outside of school	65.1%	33.3%	1.6%
04d	Do you belong to a club outside of school	22.5%	75.1%	2.4%

Sixty five percent of students reported that they study something in classes outside of school. While only 22.5% indicated that they participate club outside of school. Only 54.3% students reported that they play outside of the school and only 46.6% engaged that aesthetics outside of school.

Chi-Squared Test:

Table 4. 16 Chi-Squared Test

	Variables	Gender	Ethnicity	School Type
04a	Do you play outside of school	Significant	Significant	Significant
04b	Do you often engage in dancing/music/ art outside of school	Not Significant	Significant	Significant
04c	Are you studying something in a class outside of school	Not Significant	Not Significant	Significant
04d	Do you belong to a club outside of school	Significant	Significant	Significant

There are significant differences in relation to playing outside, participating clubs outside of school by gender, ethnicity, and school types. There is no significance difference between participation in aesthetics activities outside of school. Similarly, there is no significance difference by gender and ethnicity in participation in a class outside of school.

4.2.3.3 Co-curricular Mathematics activities

Table 4. 17 Co-curricular Mathematics activities

Variable	Yes	No	Missing
In this school year, are you preparing for or have you participated in Mathematics Camps	65.1%	33.3%	1.6%
In this school year, are you preparing for or have you participated in Mathematics Club	22.5%	75.1%	2.4%
In this school year, are you preparing for or have you participated in Mathematics Competitions	15.5%	80.7%	3.9%

Only 65.1% students indicated that they participated in Mathematics camp during the school year. Student's participation in Mathematics clubs and Mathematics competitions indicate low percentages as per the above table.

Table 4. 18 Chi- squared Test

Variable	Gender	Ethnicity	School Type
In this school year, are you preparing for or have you participated in Mathematics Camps	Not Significant	Significant	Significant
In this school year, are you preparing for or have you participated in Mathematics Club	Not Significant	Significant	Significant
In this school year, are you preparing for or have you participated in Mathematics Competitions	Not Significant	Not Significant	Significant

There was no significant difference by gender in participating in Mathematics camps, Mathematics clubs, and Mathematics competitions. However, there were significance difference among students' participation by school type in all three aspects. It also interesting to note that there is significance difference by ethnicity in student's participation in Mathematics camps and Mathematics clubs.

4.2.4 Home Environment related factors from the perspective of the students

4.2.4.1 Support from home

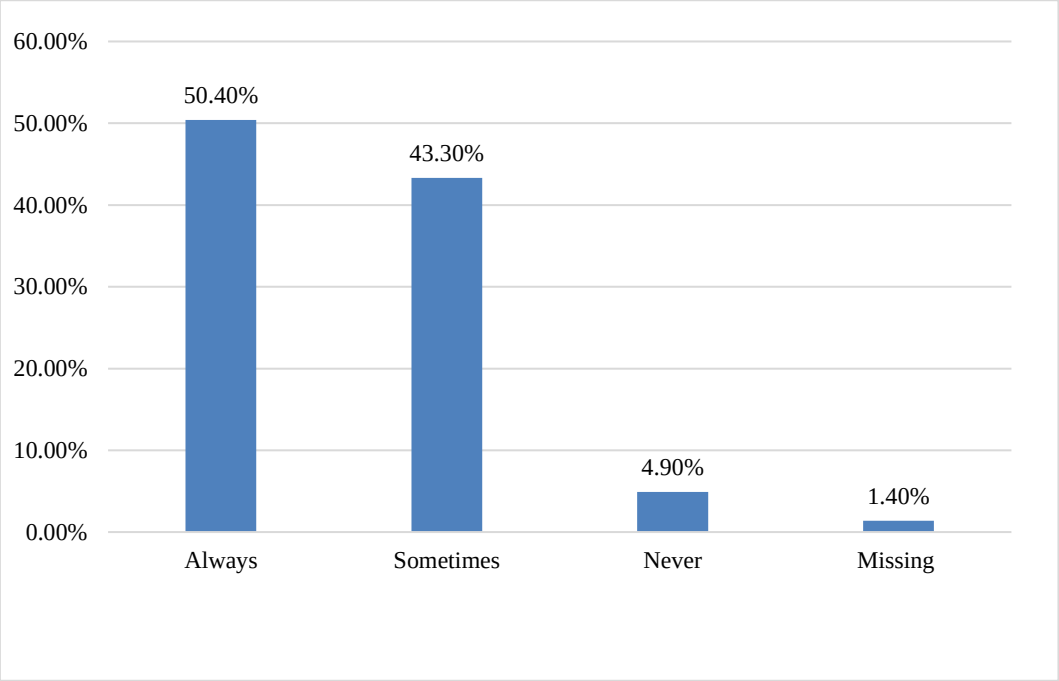

Figure 4. 9 Support from home

Only 50.40% of students always receive support from home for learning mathematics while 43.3% indicate that they receive support sometime. Nearly 4.9% of students never received support from home.

Hypothesis Testing

Table 4. 19 Hypothesis Testing

	P-value	Decision
Gender	0.077	Do not reject H_0
Ethnicity	0.000	Reject H_0
School Type	0.000	Reject H_0

There was no significance difference by gender (p= 0.077) about the support the students received from home for learning Mathematics. However, there were significance differences by ethnicity (p= 0.000) and school type (p= 0.000) about the support the students received from home for learning Mathematics.

4.2.4.2 Parental Education Level

Table 4. 20 Parental Education Level

Education Qualification	Highest Education qualification of mother	Highest Education qualification of Father
Less than O/L	17.4%	18.3%
O/L	22.3%	16.9%
A/L	16.7%	16.0%
Diploma	2.1%	2.4%
Degree	3.3%	2.5%
Post graduate degree or professional degree	1.7%	0.9%
PhD	1.3%	1.1%
I do not know	33.8%	40.1%
Total	98.6%	98.2%
Missing	1.4%	1.8%
Total	100.0%	100.0%

Mother's level of education of the students indicates that 40% of mother's have studied up to or less than G.C.E. Ordinary level. Another 18% have Advance level qualifications or diploma level. About 6% of mothers have either degree level or postgraduate level of qualification. Father's qualifications also indicate a similar pattern. An interesting point to know was that 40% of students did not know their parents' educational qualifications.

4.2.4.3 Home Environment

Table 4. 21 Availability of books at home (except magazines, newspapers, and textbooks)

No. of books	0-10	11-25	26-100	101-200	> 200	Missing
Frequency	34.9%	34.5%	18.6%	4.5%	6.2%	1.2%

Nearly 70% of households had less than 25 books. About 28% of the household had 26 to 200 books. Thus, indicating that most students lacked enough books for reading at home.

4.2.5 Teacher Related Factors affecting student achievement

The effect size measures can be used for determining the strength of association between variables (Maher, Markey and Ebert-May, 2013).

As shown in the Figure 4.10, in-service training (η^2=0.74), teachers' self-efficacy (η^2= 0.63), identification of curriculum objectives (η^2=0.60), teacher workload and working conditions (η^2=0.58), parental expectations and support (η^2=0.55), academic climate in the school (η^2=0.49), student related limitations affecting teaching (η^2=0.45), homework (η^2=0.41), physical facilities for teaching (η^2=0.39), job satisfaction of the teachers (η^2=0.37), professional interactions with other teachers (η^2=0.29) and classroom teaching practices (η^2=0.27) have large effect size (η^2>0.14) (Cohen, 1992, 1988; Rosenthal, 1996) indicating a stronger association students' achievements. Meanwhile, safety, behaviour, and assessment have medium effect size (0.01<η^2<0.14) (Cohen, 1992, 1988; Rosenthal, 1996) indicating a weak association with students' marks.

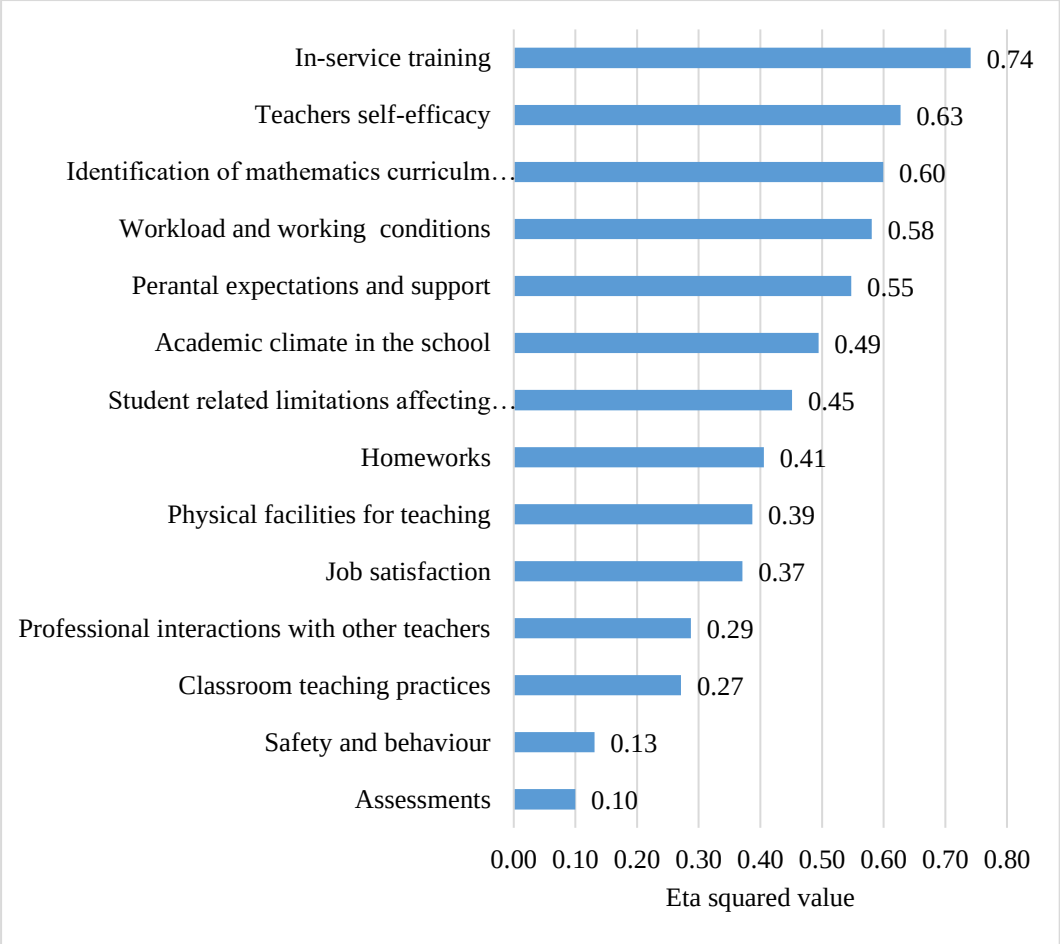

Figure 4. 10 Effect size measures

4.2.5.1 Teachers' profile based on teaching experience

Table 4. 22 Teachers' profile based on teaching experience

Teaching Experience	Frequency	Percentage
1 – 5 years	22	44
5 – 10 years	06	12
More than 10 years	22	44
Total	50	100

Table 4.22 represents teachers teaching experience. Out of all the mathematics teachers 44% have less than 5 years of experience, 12% have between 5-10 years of experience and 44% have more than 10 years of experience.

Table 4. 23 Teachers' profile based on age

Age in Years	25-29	30-39	40-49	50-60
Percentage	34%	30%	18%	18%

The age of 64% of the selected teachers are below 40 years old.

Table 4. 24 Respondents' profile based on educational qualifications

Educational Qualification		Frequency	Percentage
G.C.E. (O/L)		02	04
G.C.E. (A/L)		31	62
Degree	Mathematics	08	16
	Biology	01	02
	Commerce	05	10
	Arts	02	04
	Education	01	02
	Sub-Total	17	34
Total		50	100

The respondents' profile based on their highest educational qualification is shown in the Table 4.24., Most of the mathematics teachers (66%) have G.C.E. (O/L) and G.C.E. (A/L) qualifications while 34% of mathematics teachers are degree holders. Out of them, only 16% of teachers have offered mathematics as a subject in their first degree.

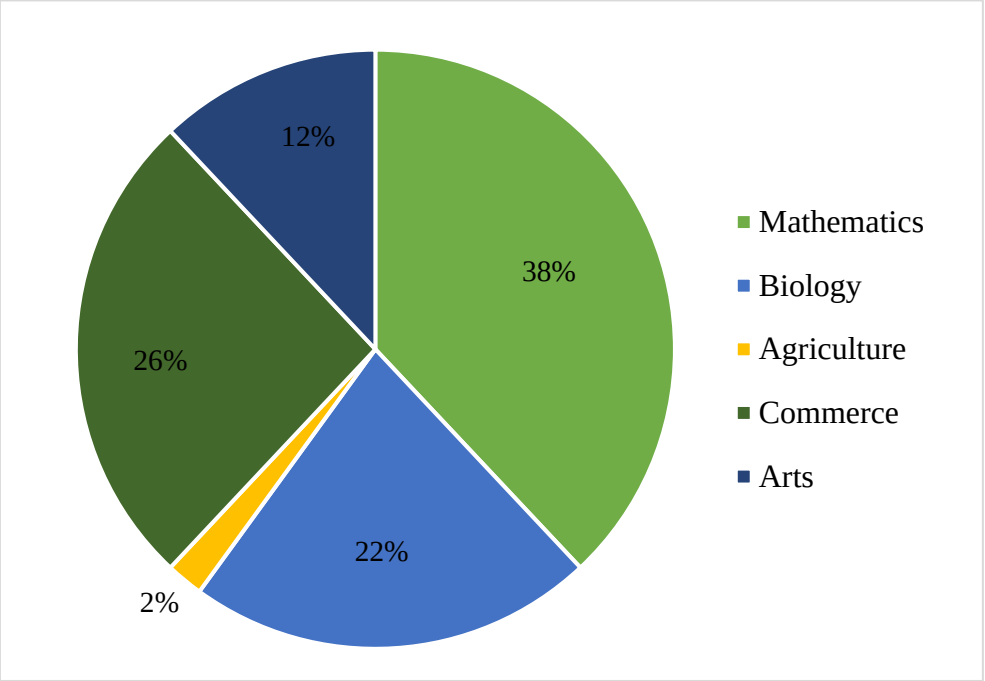

Figure 4. 11 Subjects offered at the G.C.E. Advanced Level

As shown in the Figure 4.11, 38% of mathematics teachers at the selected sample were studied mathematics for their G.C.E. (A.L.) while 22% of the teachers studied biology. Only 60% of teachers studied at the science stream for their ALs.

Table 4. 25 Respondents' profile based on professional qualifications

Professional Qualification	Frequency	Percentage
Trained Teacher Certificate	19	38
National Diploma in Teaching	12	24
Postgraduate Diploma in Education	03	06
Bachelor of Education	05	10
None of the above qualifications	11	22
Total	50	100

As shown in Table 4.25, 78% of mathematics teachers have professional qualifications while 22% do not have any professional qualification in teaching.

4.2.5.2 Academic climate and the support for teachers

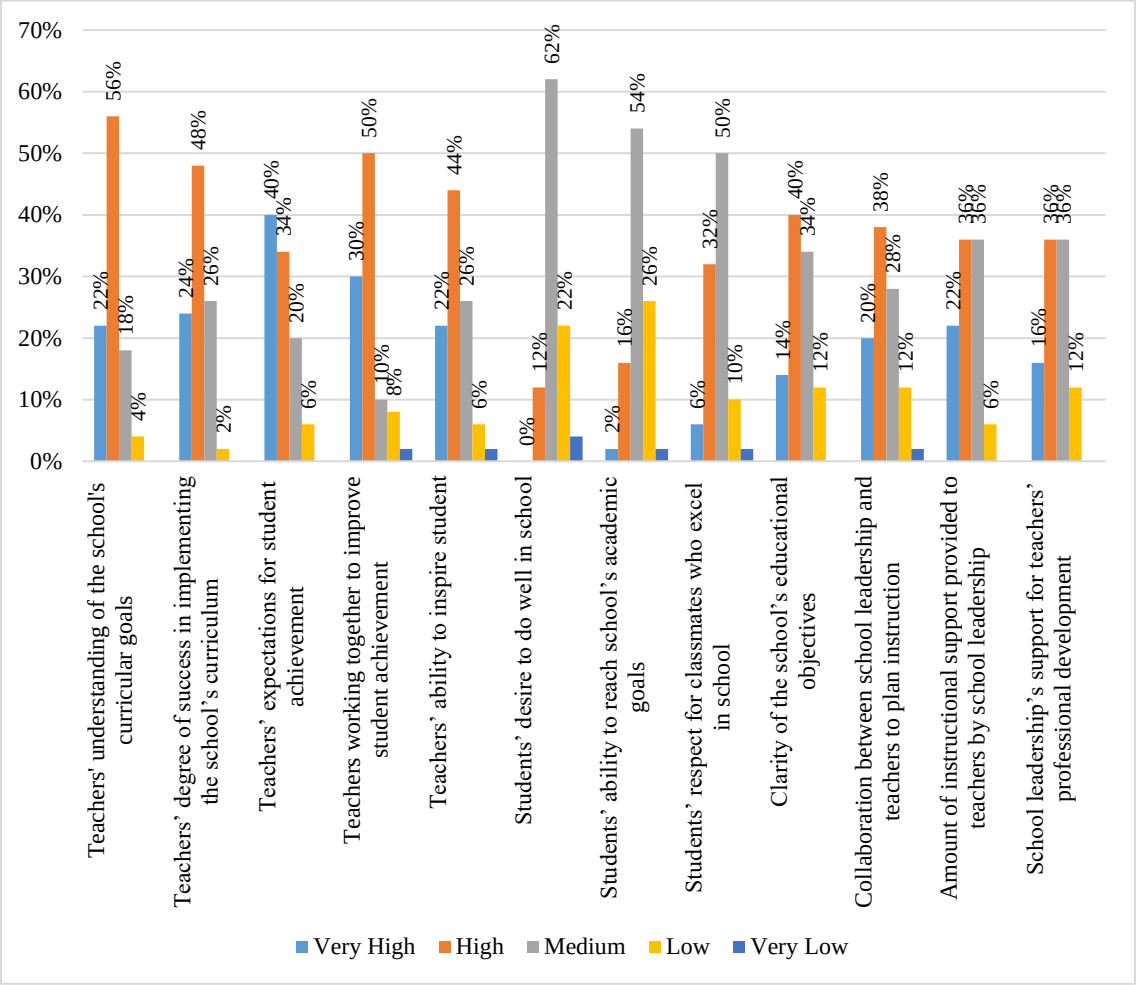

Figure 4. 12 Academic climate in the school and the support received by teachers

As shown in the Figure 4.12, teachers' beliefs about their confidence in understanding and implementing the curriculum is particularly good. Most teachers (65%-80%) rated that teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school curriculum, teachers' expectations for students' achievement, working together to improve student achievement and teachers' ability to inspire students as very high or high.

However, teachers indicated that they were less confident about student learning and behaviour. Most of the teachers (20% -22%) rated: students desire to do well in the school; students' ability to do well in the school and students' ability to reach school's academic goals as low, or very low. Meanwhile, (60%) of teachers rated students' respect for classmates who excel in the school is low or very low.

Teachers also rated: clarity of the school's educational objectives (46%), the collaboration between school leadership and teachers to plan instruction (42%), amount of instructional support provided to teachers by school leadership (42%) and school leadership's support for teachers' professional development (48%) as low or very low (minimal).

4.2.5.3 Parental expectations and support

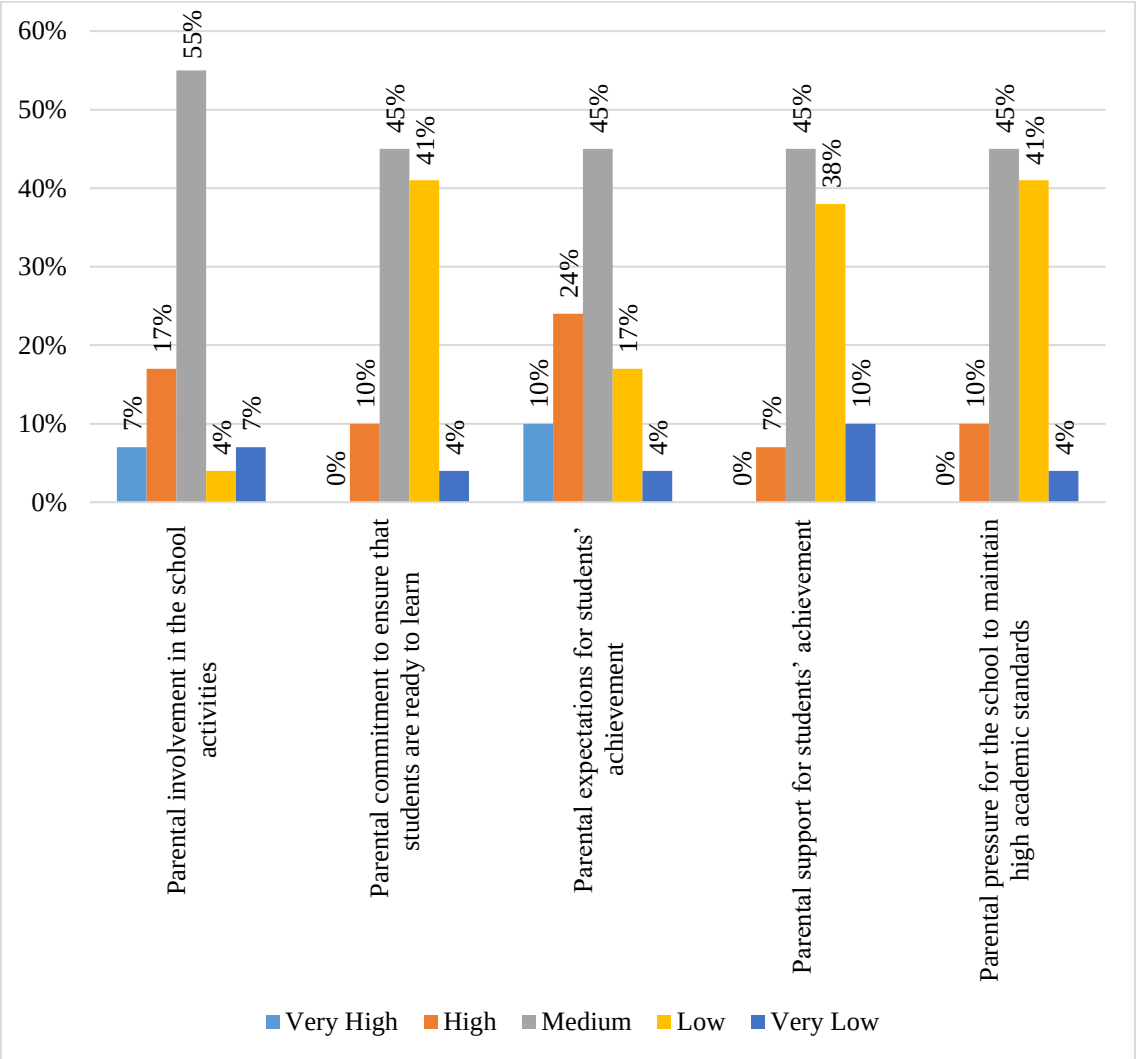

Figure 4. 13 Parental expectations and support

According to the Figure 4.13, teachers rated parental expectations and their support to students' education as minimal. All the items under this scale showed low percentage values in the very high and high categories: parental involvement in the school activities (24%); parental commitment to ensure that students are ready to learn (10%); parental expectations for students' achievement (34%); parental support for students' achievement (7%); and parental pressure for the school to maintain high academic standards (10%).

4.2.5.4 Safety and student behaviour

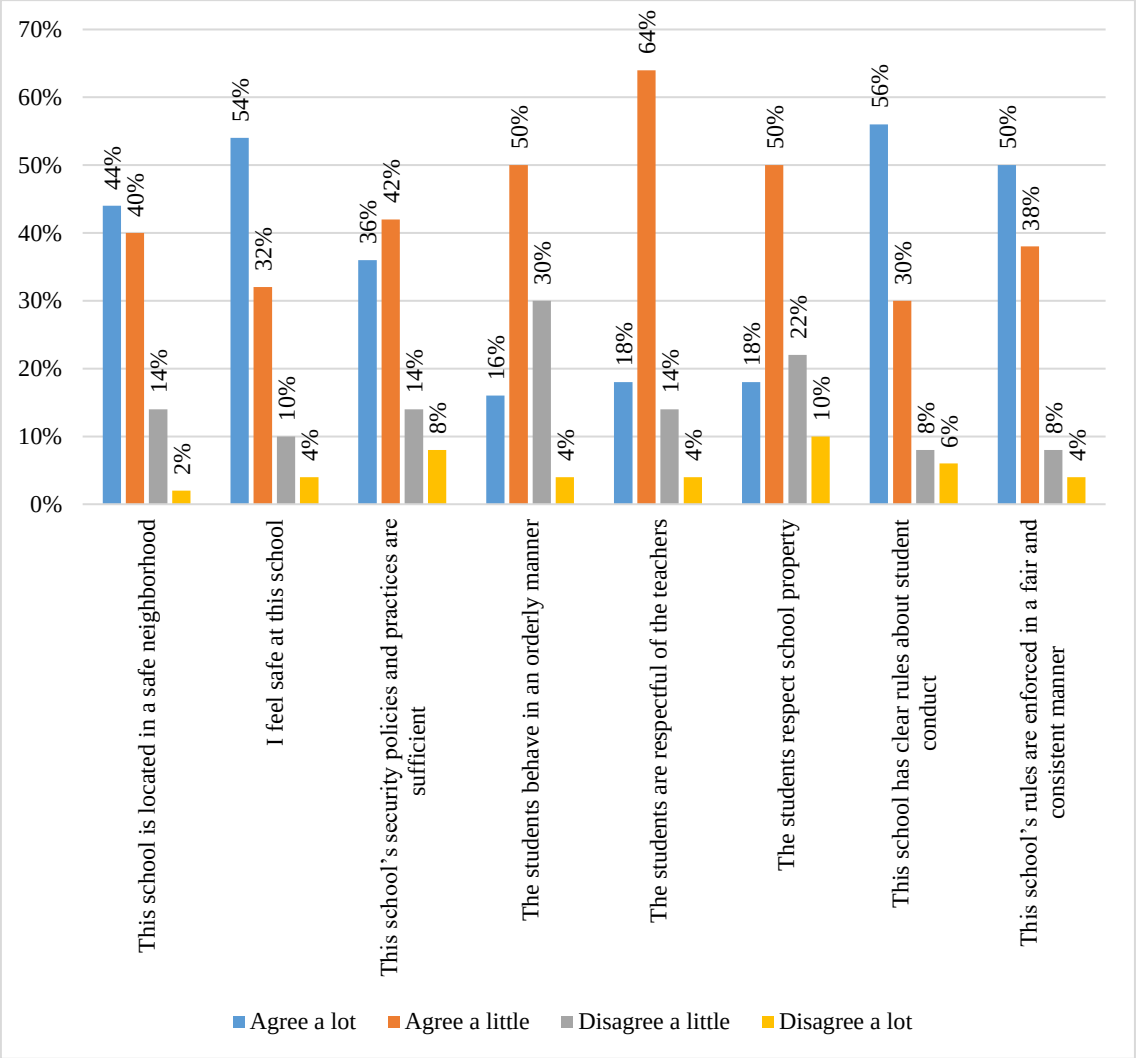

Figure 4. 14 Safety and Student behaviour

As shown in the Figure 4.14, according to the teachers' point of view the safety and behaviour of the students in the schools is at a particularly satisfactory level. The items in this subscales showed higher percentages in the Very high and High categories: this school is located in a safe neighbourhood (84%); I feel safe at this school (86%); This school's security policies and practices are sufficient (78%), the students behave in an orderly manner (66%), the students are respectful of the teachers (82%), the students respect school property (68%), this school has clear rules about school conducted (86%), and this school's rules are enforced in a fair and consistent manner (88%).

4.2.5.5 Physical facilities for teaching

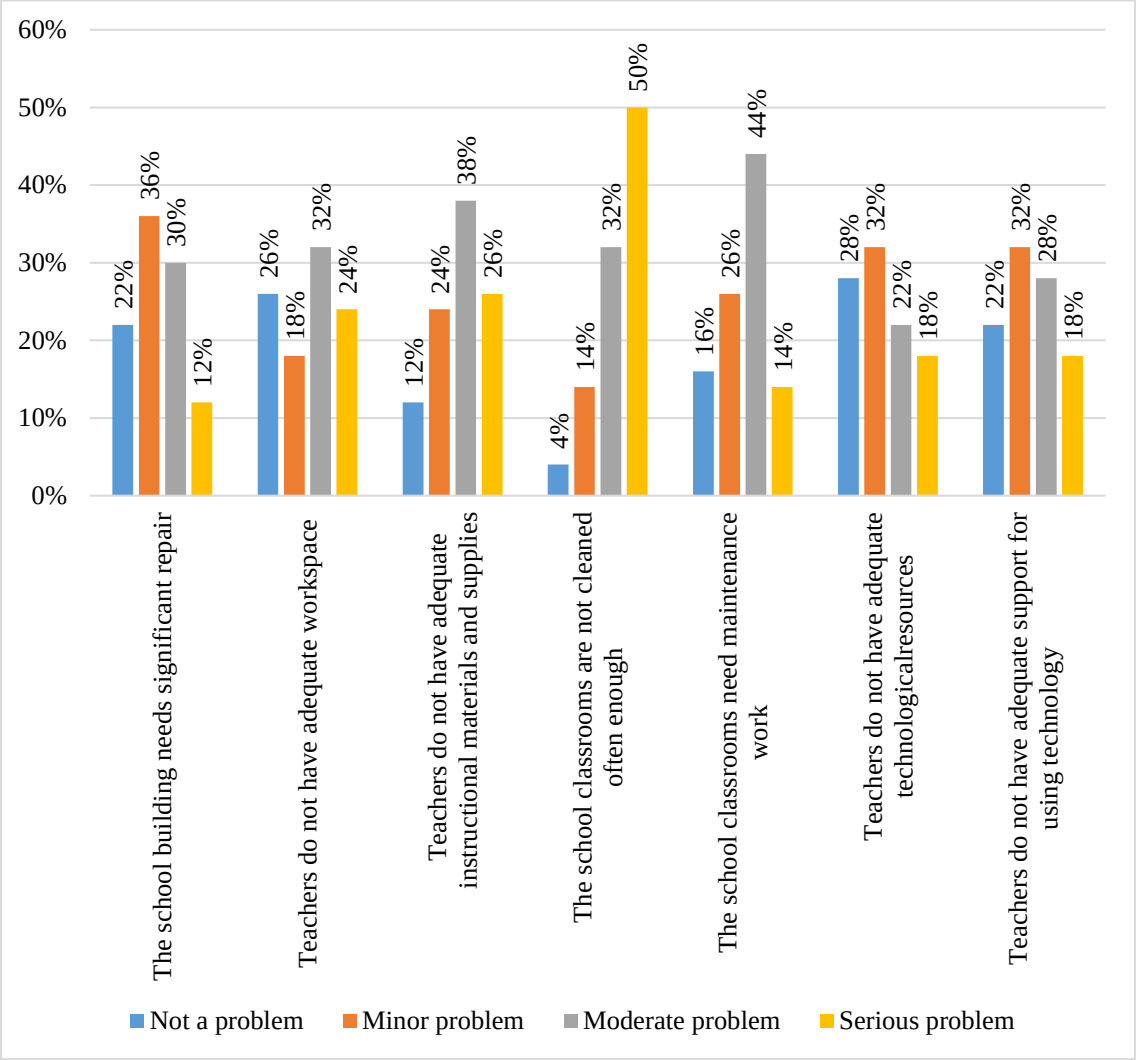

Figure 4. 15 Physical facilities for teaching

As shown in the Figure 4.15, most teachers reported that facilities for teaching in the classroom was not at a satisfactory level. According to the teachers' responses: 56% of teachers do not have adequate workspace, 64% teachers do not have adequate instructional materials and supplies, 82% of the school classrooms are not cleaned often enough and the (58%) of school classrooms need maintenance work. Forty percent of the teachers do not have adequate technological resources and 46% of the teachers do not have adequate support for using technology.

4.2.5.6 Professional interactions with other teachers

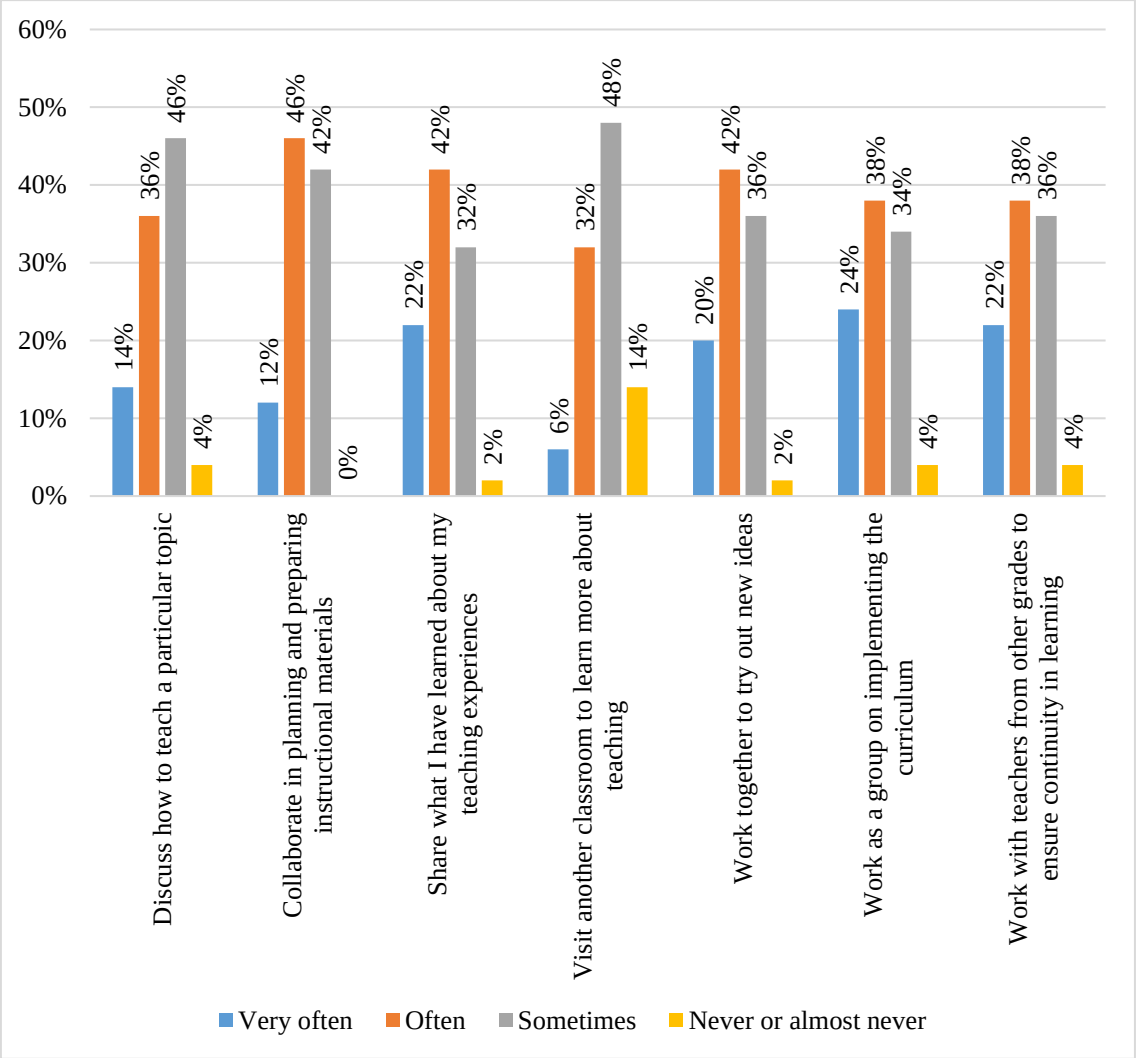

Figure 4. 16 Professional interactions with other teachers

According to the Figure 4.16, teachers indicate that professional interactions with other teachers does not happen very often. Sharing teaching experiences, work together to try out new ideas, work as a group on implementing the curriculum and work with teachers from other grades to ensure continuity in learning, collaborating in planning and preparing instructional materials, visiting another classroom to learn more about teaching are reported as happening very often among approximately 20% or less teachers in the selected sample.

4.2.5.7 Job satisfaction

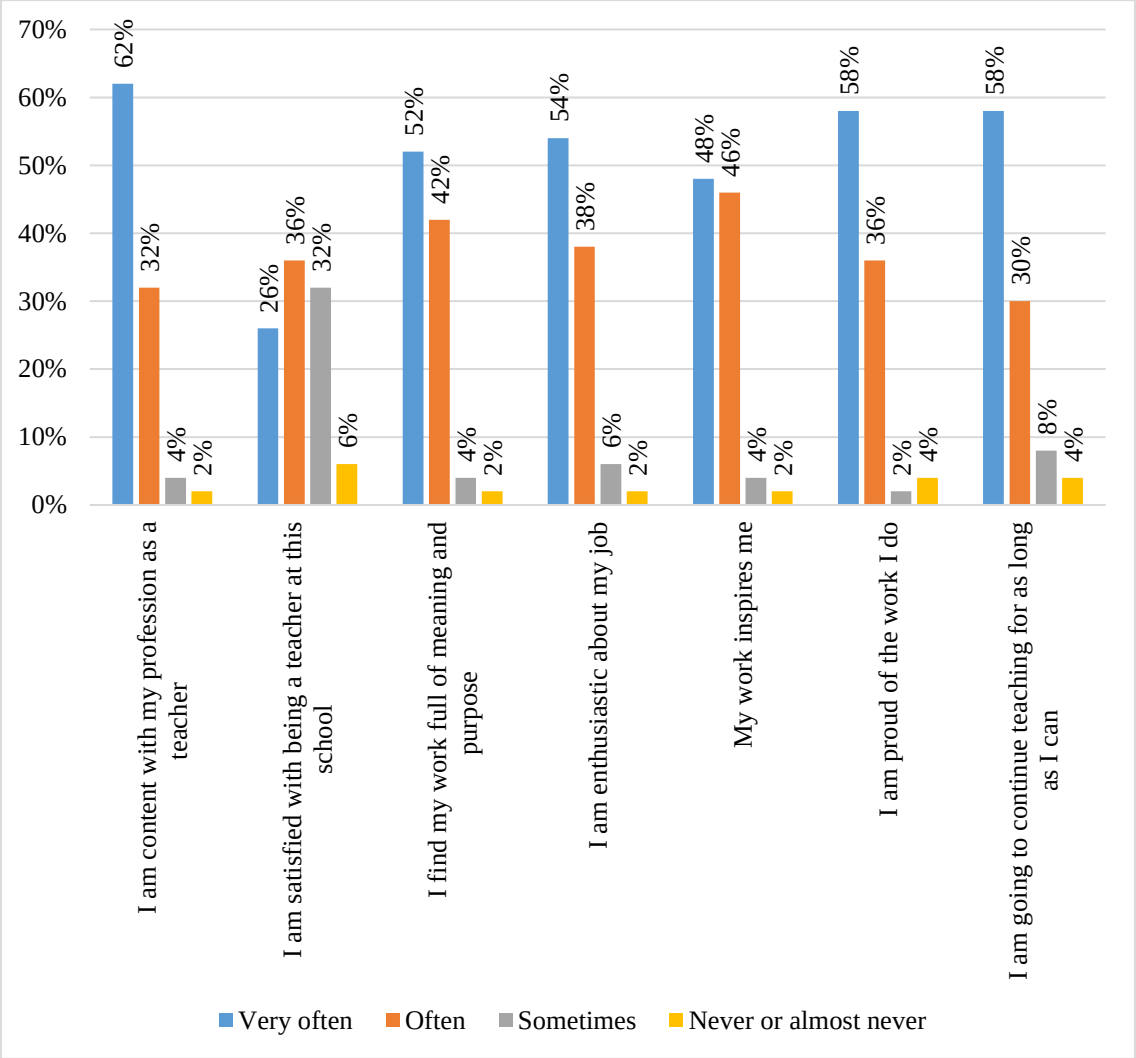

Figure 4. 17 Professional satisfaction

As shown in the Figure 4.17, most of the teachers in the selected sample is satisfied about their profession. However about 2%-6%of teachers indicated that they were never or almost never satisfied about: their profession as a teacher, being a teacher in the current school; find their work full of meaning and purpose; enthusiastic about the profession; inspired by their work; proud of the work they do or about continuing teaching for as long as they can. All items in this subscale except the item on 'being a teacher in the current school' indicated remarkably high percentages (more than 90%) of satisfaction about the profession.

4.2.5.8 Workload and working conditions

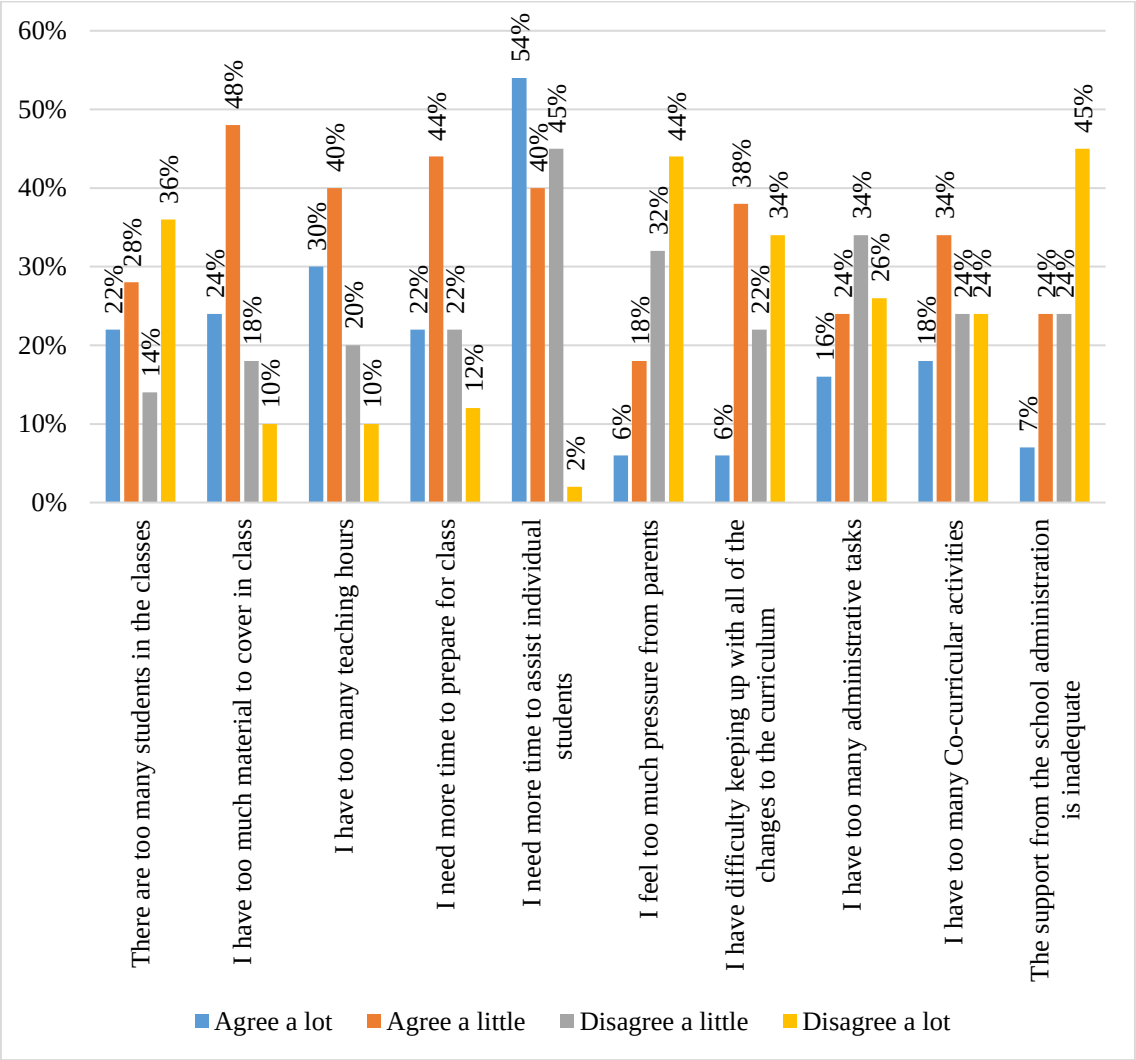

Figure 4. 18 Workload and working conditions

As shown in the Figure 4.18, the workload of the mathematics teachers in the selected sample is at a quite elevated level. Teachers reported that; there are too many students in the classroom (22%), I have too much material to cover in this class (24%), I have too many teaching hours (30%) and I need more time to assist individual students (54%). Despite the heavy workload, most teachers rated working conditions in their schools as satisfactory. The items in this subscale recorded lower percentages in the category of 'agree a lot' in relation to; I feel too much pressure from parents (6%), I have difficulty keeping up with all of the changes to the curriculum (6%), I have too many administrative tasks (16%), I have too many co-curricular activities (18%) and the support from the school administration is inadequate (7%).

4.2.5.9 Teachers' objectives for teaching mathematics in their classrooms

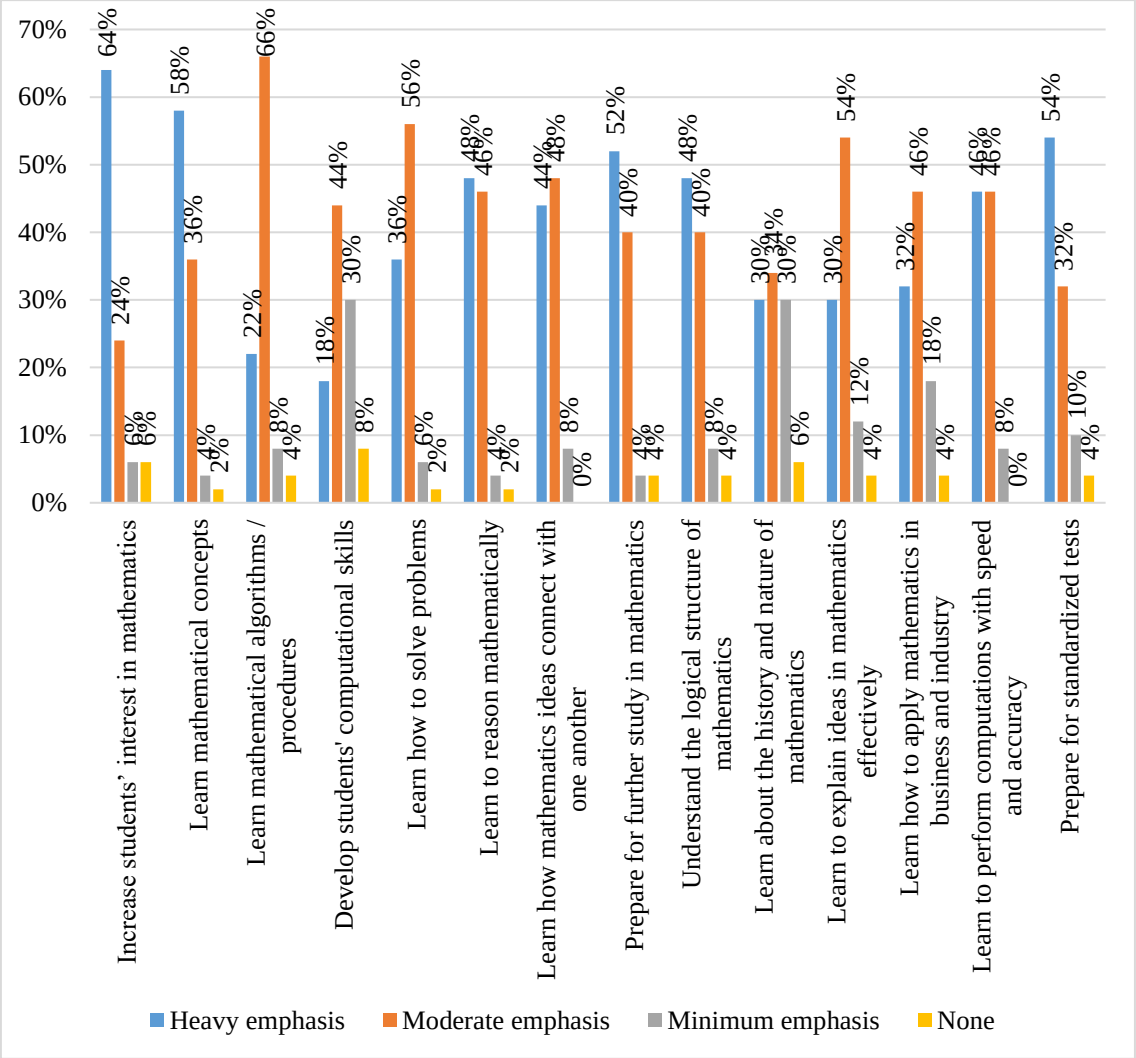

Figure 4. 19 Objectives of teaching mathematics in their classrooms

Most of the mathematics teachers in the selected sample emphasised the objectives stated in the Figure 4.19 when teaching mathematics. Sixty four percent of teachers heavily emphasised increasing student interest in mathematics. However, some of the mathematics teachers did not heavily emphasise more important objectives of learning mathematical algorithms/ procedures (22%), developing students' computational skills (18%), learning how to solve problems (36%), learning about the history and nature of mathematics (30%), learning to explain ideas in mathematics effectively (30%) and learning how to apply mathematics in business and industry (32%).

4.2.5.10 Classroom teaching practices

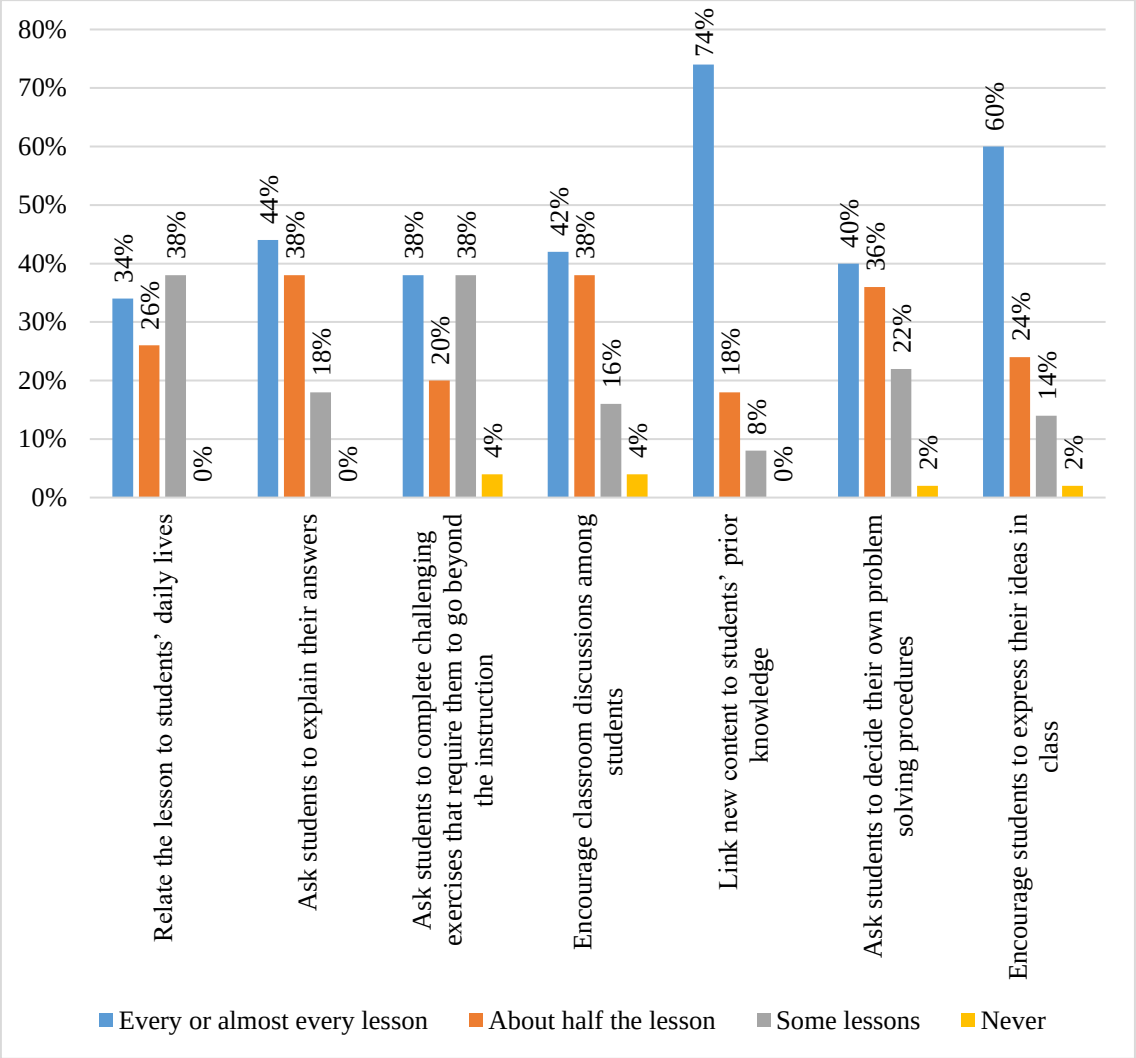

Figure 4. 20 Classroom teaching practice

As shown in the Figure 4.20, the mathematics teachers in the selected sample: related lessons to students' daily lives 34%, ask students to explain their answers 44%, ask students to complete challenging exercises that require them to go beyond the instructions 38%, encourage classroom discussions among students 42%, link new concepts to students' prior knowledge 74%, ask students to decide their own problem solving procedures 40% and encourage students to express their ideas in class in every or almost every lesson 60%. Less than 4% of teachers are not implementing above strategies when teaching mathematics to the classroom.

4.2.5.11 Student related limitations affecting teaching

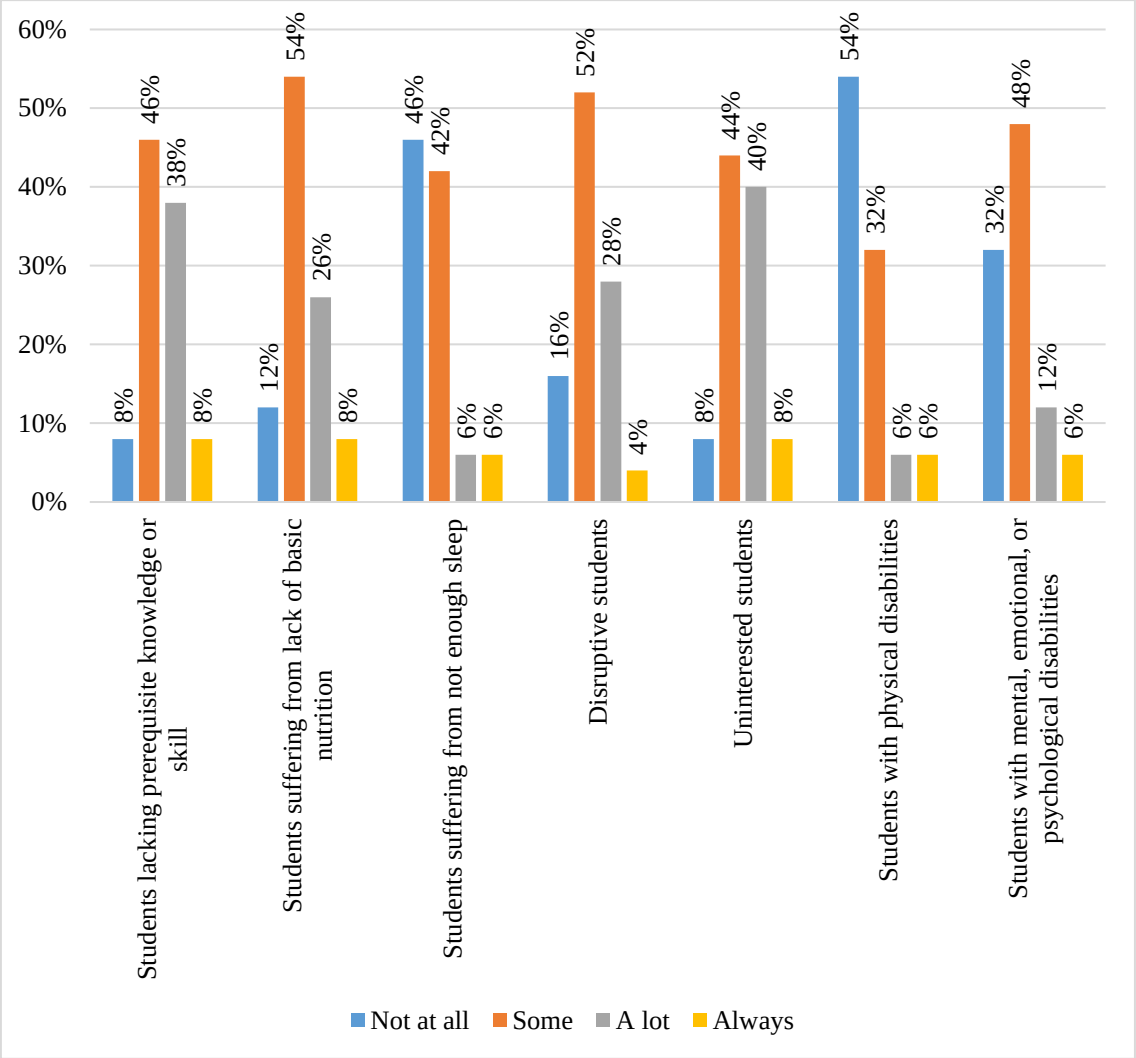

Figure 4. 21 Student related limitations affecting teaching

As shown in the Figure 4.21, a small percentage of teachers indicated that students in the selected classroom are always lacking prerequisite knowledge or skill (8%), suffering from lack of basic nutrition (8%), suffering from not enough sleep (6%), disruptive students (4%), uninterested students (8%), students with physical disabilities (6%) and students with mental, emotional, or psychological disabilities (6%). However, 32%-50% of0.32 the teachers reported that students sometimes show the above stated limitations when teaching mathematics in the classroom.

4.2.5.12 Teachers' self-efficacy

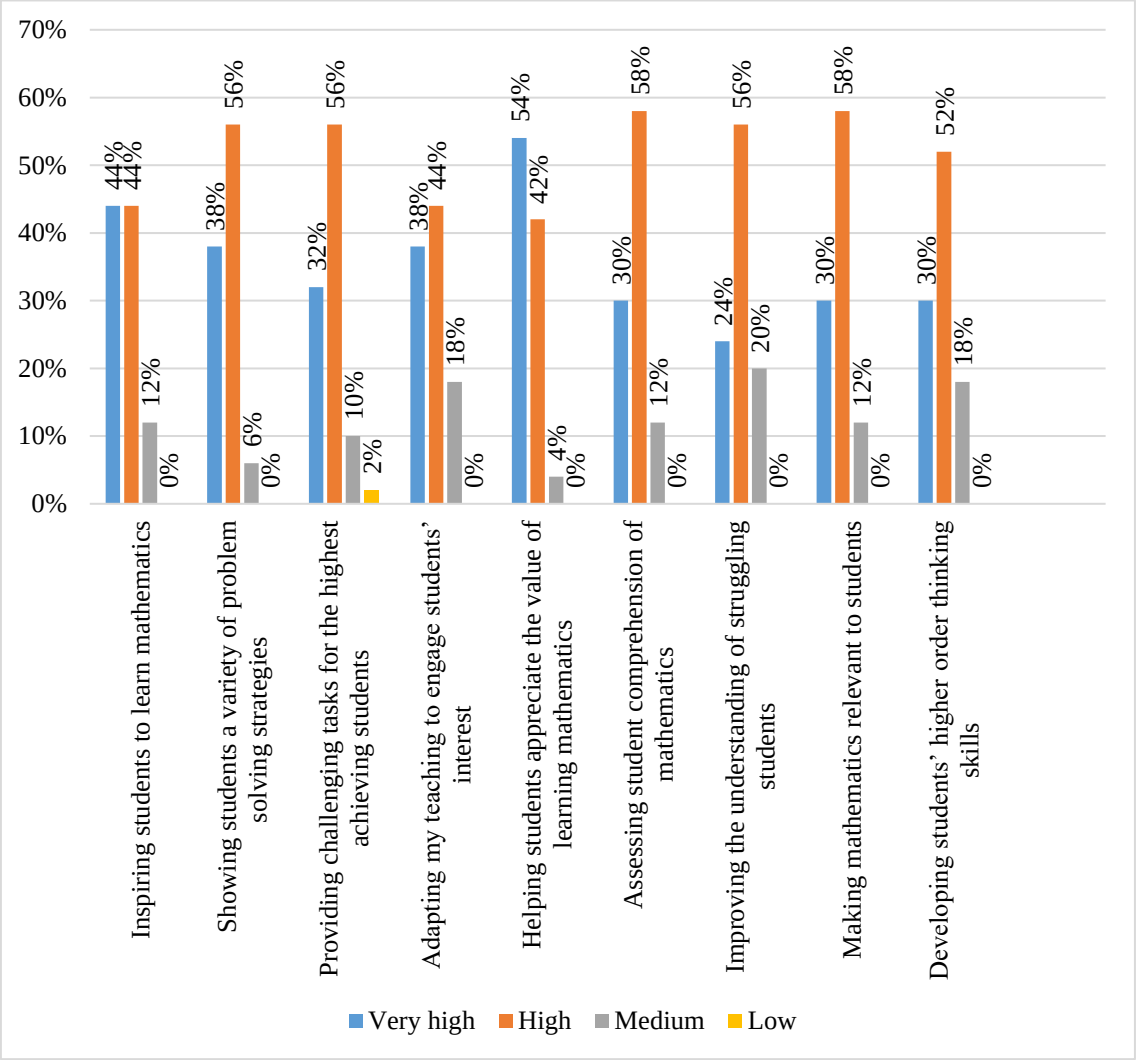

Figure 4. 22 Teachers' self-efficacy

According to the Figure 4.22, teachers indicate a very high-level self-efficacy beliefs in mathematics teaching. Accordingly Mathematics teachers indicated that they are: able to inspire students to learn mathematics (88%); showing students a variety of problem-solving strategies (94%), providing challenging tasks for the highest achieving students (88%), adapting their teaching to engage students' interest (82%), helping students appreciate the values of learning mathematics (96%), assessing student comprehension of mathematics (88%), improving understanding of struggling students (80%), making mathematics relevant to students (88%) and developing students' higher order thinking skills (82%).

4.2.5.13 Homework

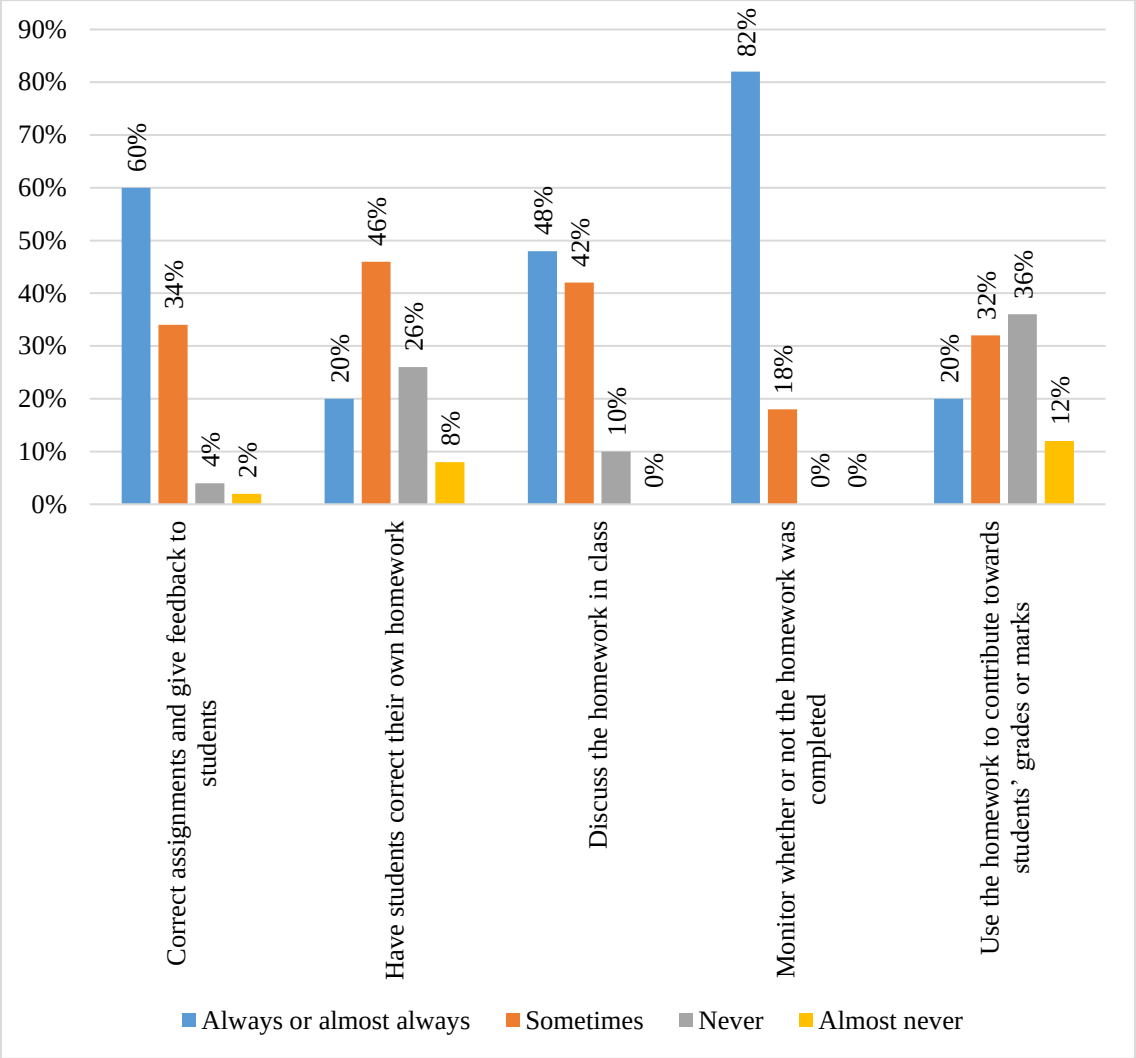

Figure 4. 23 Homework

According to the Figure 4.23, 60% of teacher's correct assignments and give feedback to students, 48% discuss the homework in class and 82% monitor whether the homework was completed always or almost always. However, the use of homework marks in grading students is practiced by a small percentage of teachers.

4.2.5.14 Assessment

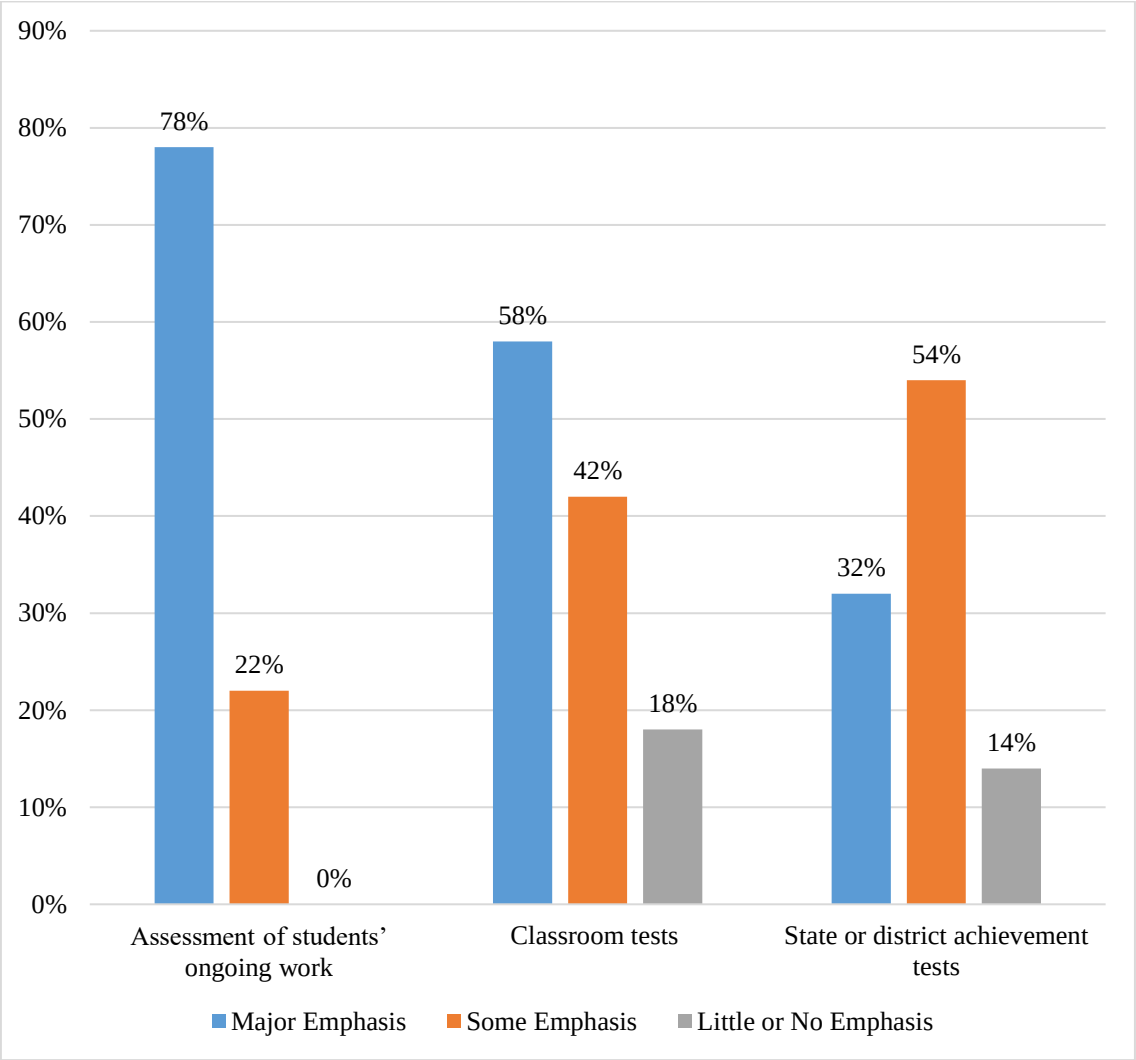

Figure 4. 24 Assessment

According to the Figure 4.24, to monitor students' progress in mathematics teachers reported that they place major emphasis on the assessment of students' ongoing work (78%), classroom test (58%) and state or district achievement tests (32%).

4.2.5.15 In-service Education and training

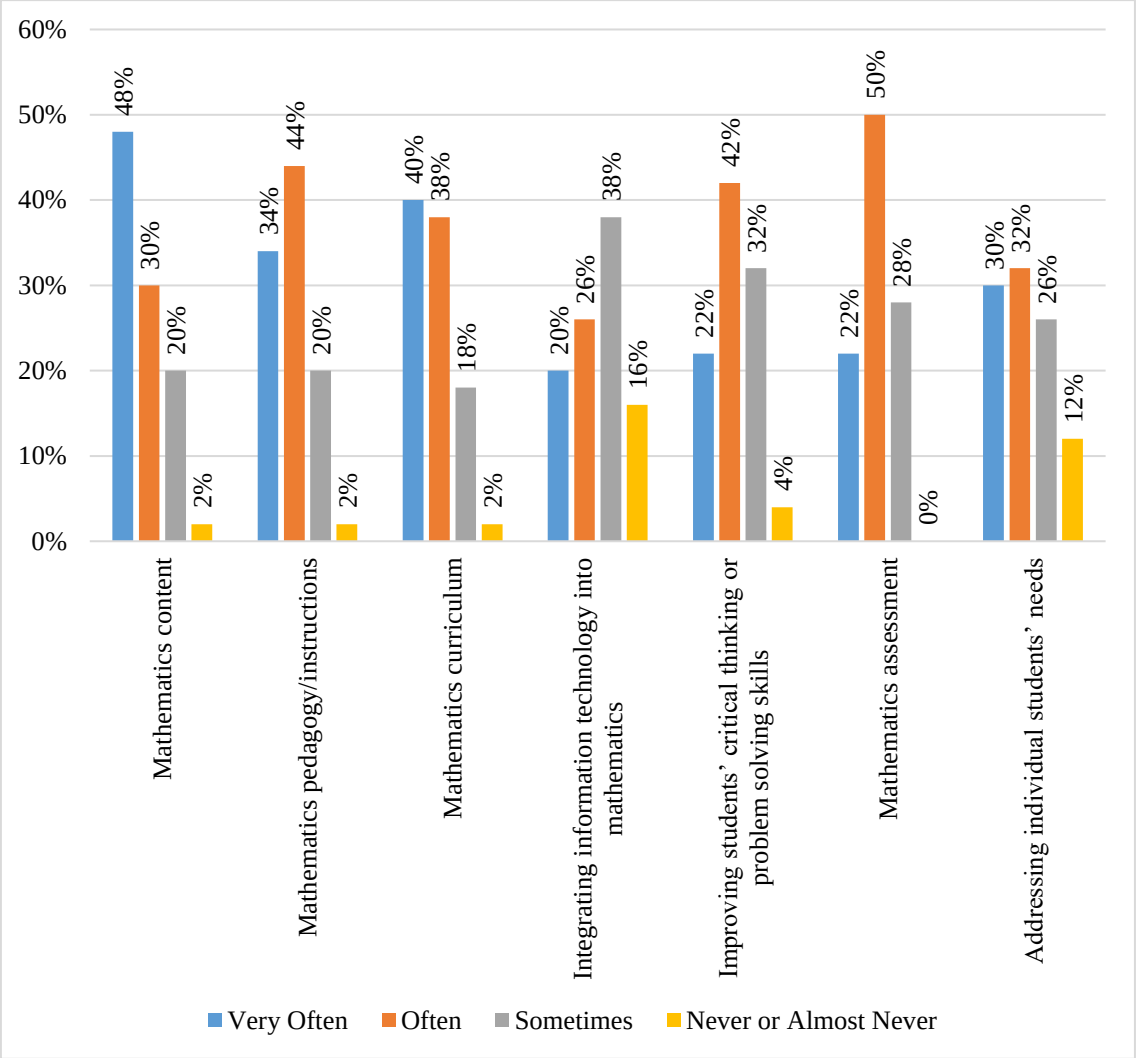

Figure 4. 25 In-service teacher training

As shown in the Figure 4.25, most of the in-service teacher programmes very often focused on mathematics content (48%), mathematics pedagogy/ instructions (34%) and mathematics curriculum (40%). But the officials are less frequently arranging the teacher training programmes of integrating information technology into mathematics (20%), improving students' critical thinking or problem-solving skills (22%), mathematics assessment (22%) and addressing individual students' needs (30%).

4.2.6 Teachers views expressed in the interviews on factors affecting students' poor achievements and the strategies used by teachers

In this section we present the analysis of interview data pertaining to teachers views on reasons for students' poor achievements in mathematics and their current and suggested strategies for improving students' achievements in mathematics. Six main themes emerged in the analysis of data on the first research question related to the teachers' views on students' low achievements in mathematics and their strategies for improving students' achievements, namely,

- *students' factors affecting mathematics achievements*,
- *factors pertaining to students' home environment*,
- *factors related to school,*
- *factors related to curriculum,*
- *Teacher's strategies of teaching,* and
- *Complex interaction of many factors*.

4.2.6.1 Students' factors affecting mathematics achievements

The teachers' views focused on students' interests, attitudes and motivations, prior knowledge, language ability and cognitive skills such as memory, attention, logical thinking, and reasoning. Students' dislike and fear of mathematics as well as lack of motivation to learn mathematics seem to have made teachers helpless or to take aggressive measures. For example, one teacher elaborated that:

> Most of the students dislike mathematics. They prefer if the teacher does not come to the class. It is a challenge for me and most of the time I must force them to learn, using different strategies such as threatening to use punishments etc.
>
> - (Teacher 0212)

Another teacher reported:

> Students fear mathematics. They have an attitude that they cannot learn. It may be a result of receiving poor marks in previous grades. So, they think mathematics is difficult and achieving high scores is impossible. Even if we assign a task, they do not even try to do it. They have a negative attitude towards mathematics.
>
> - (Teacher 0208)

Teachers also reported that students' low achievements are due to students' lack of prior knowledge, language ability and cognitive skills such as memory, attention, and perception. One teacher articulated the situation as follows:

> I start from grade six, the children coming from the primary do not have the basic mathematical concepts. There are students who cannot even write numbers correctly. Some students cannot read word problems; they can sometimes give the correct answer if we read the problem for them. Individual differences also matter in perception of mathematical concepts, there are very clever students who could understand at the very first instance, then there are others who cannot understand anything. We must deal with both groups at the same time
>
> -(Teacher 0103)

Mullis et al (2012) also indicate that students' lack of prior knowledge and skills affect their mathematics achievements. The importance of prior knowledge in learning new things is highlighted in cognitive and constructive theories of learning. "Every new thing that a person learns must be attached to what the person already knows" (McLaughlin et al., 2005, p. 5).

Factors pertaining to students' home environment

Teacher beliefs of students' home environment related factors included parent's education level, their habits at home, support that can be provided by parents, their attitudes towards learning mathematics and level of intelligence as reflected in the following extracts from the interview transcripts:

> They have so many family problems, so they are not mentally ready for studying. Most of the families in this area having 'disk TV' connection. So, after school hours all the family members watch TV. So, it is very difficult to control them (students), their concentration skills are so poor.
>
> - (Teacher 1134)

> They think that mathematics is a difficult subject for the generations. Parents also think that they cannot learn mathematics. So, they are unable to help their children at home to learn mathematics.
>
> - (Teacher 0321)

> There are no family problems. Both parents are there, however parents are inherently ...mm… less intelligent.
>
> - (Teacher 0331)

Research consistently shows a strong positive relationship between achievement and socioeconomic indicators such as parents' or caregivers' level of education or occupation, facilities at home environment and parental attitudes towards education (Mullis et al, 2012; Alghazo & Alghazo, 2015; Lamb and Fullarton, 2015).

Factors related to school

Factors related to school, included the lack of human and physical resources, and teacher's workload. Some typical responses in relation to these aspects were as follows:

> Our main problem is the lack of resources, the classroom environment is not suitable for active learning.
>
> - (Teacher 1347)

> Lack of equipment is a problem. We do not have a mathematics lab and we must prepare teaching learning aids such as shapes etc. by ourselves. The school has only one compass.
>
> - (Teacher 0329)

Another teacher elaborated on the lack of enough qualified mathematics teachers in the schools:

> There should be teachers qualified to teaching maths in a school. In my school I must teach IT, commerce, and art in addition to Mathematics in grade 7. As a teacher I must spend my time to plan subjects in a wide range. It is a problem for me to teach mathematics well because I must focus on other 03 subjects also.
>
> - (Teacher 0323)

Factors related to curriculum

Teachers attribute complexity, lack of gradual progression and content overload in the curriculum as well as the lack of supplementary curriculum materials as reasons for students' low achievements. Following extracts from the interview transcripts elaborate the situation:

> There is a sizable increase (in content) in grade 7 curricula compared to grade 6. Clever students can catch up, but weaker students find it difficult to learn mathematics, so I suggest reducing the gap between grade 6 and grade 7. … This problem does not occur in grade 8 and 9.
>
> - (Teacher 0209)

> The curriculum is too complex in some grades. What they do in curriculum revision is putting the grade 9 content into grade 8. Then the teachers in these types of schools get into trouble. So, it is necessary to reduce the complexity of the curriculum or otherwise reduce the number of lessons. There is a problem of covering the syllabus in time.
>
> - (Teacher 0216)

> It would be better to ask students to solve math problems using various sources in addition to their textbook as the math textbook contains only limited exercises.
>
> - (Teacher 0214)-

Complex interaction of many factors

Many of the teacher responses suggested that they believe poor achievement is mostly due to many interacting factors such as students' lack of prior knowledge, difficulties in dealing with individual differences and especially with students at diverse levels of abilities in the same class and parents' ignorance or lack of support from the home environment and lack of facilities in schools. For instance, one teacher articulated the situation in her mathematics class as follows:

> The children coming from the primary do not have the basic mathematical concepts. Some students cannot even write numbers correctly. Some students cannot read word problems; they can sometimes give the correct answer if we read the problem for them. Individual differences also matter in the perception of mathematical concepts. Clever students could understand at the very first instance, and then others cannot understand anything. We must deal with both groups at the same time.
>
> -(Teacher 0103)

The teacher's response illustrates how the students' lack of prior knowledge, difficulties in reading and writing and classroom conditions affect mathematics teaching and learning in her classroom. Here the implication is that mathematics teachers need to pay more attention to the students with this type of weaknesses and incorporate adaptive teaching methods and differentiated teaching in their classrooms.

Teachers' strategies of teaching

Very few teachers reflected upon the drawbacks in their teaching and suggested that their methods of teaching and the working conditions might affect student learning. For instance, one teacher suggested:

> I think if I could use different teaching methods, I can gain the students' attention. For that, we need more instruments and facilities.
>
> - (Teacher 130/1346)

4.2.6.2 Teachers' current and suggested strategies for improving students' achievements and their implications

Teachers' current practices and suggested strategies for improving students' achievements appeared to be related to specific school contexts and pressures for improving students' scores in public examinations. Teacher responses also indicated diverse views about their current and suggested strategies.

Many teachers reported that they already use additional classes in after school hours, providing opportunities answer past papers and frequent testing. A few teachers stated that they are already working hard to improve examination results and no more work is necessary. One such teacher articulated her view as follows:

> Mathematics results is good. We make a lot of effort. We photocopy question papers and distribute among O/L students. We do lot of work and conduct extra classes after school. So, we do not need to do anymore things. Teachers already work hard.
>
> -(Teacher 0103)

Another teacher had a similar view supporting the need for 'teaching to the test' where students are exposed to additional instructions and more frequent testing to improve their test scores and examination results:

> It is good if we can have weekly tests. We do monthly tests, but it is better to give a test at the end of a unit and weekly tests. Teachers in these grades have the responsibility to give the basic concepts to the students to hand over them to O/L teacher.
>
> -(Teacher 0324)

Other teachers highlighted the lack of enough physical resources such as mathematics labs, adequate space, learning aids and technology available in the classrooms while many of them also focused on student factors and their current practices and obstacles to implement them. Following extract elaborates the stance of such teachers:

> The important thing is to provide the basic knowledge of mathematics to students. What we must do is to conduct some extra teaching after school. Even though there are free periods where we can teach mathematics students do not like to learn mathematics during those free periods. Students say, 'we get bored in learning mathematics.' Our

> principal suggested to use computers to support student's learning, but it is not easy as the students do not have adequate basic knowledge in mathematics.
>
> - (Teacher 0326)

The teacher emphasises the need to improve students' mathematical knowledge using extra classes and technology while indicating students' reluctance to learning mathematics as an obstacle. Another teacher while focusing on students' lack of prerequisite understanding of basic mathematics explained the need to provide stimulating learning aids, introducing cocurricular activities to enhance students' learning in mathematics as follows:

> Some students cannot understand what the teacher teaches. One thing we can do is to provide them opportunities to learn using learning aids where students can learn by touching and manipulating them. We can also conduct mathematics exhibitions and clubs. It will increase the competition among the children which will also enhance students' motivation towards maths learning.
>
> - (Teacher 0320)

Teachers also focused on home related factors in designing their strategies. One such teacher explained what the teachers in their school intend to do collaboratively to improve students' achievements:

> In the next term we are going to visit the slow learners' homes to meet the parents to get their support.
>
> - (Teacher 1347)

A few other teachers also expressed the view that collaborating with others will help them to teach better and emphasized the need to providing adequate time and opportunities to interact with other mathematics teachers and opportunities to share in-service training experiences.

Teachers' current practices and suggested strategies for improving students' achievements are related to specific school contexts, pressures for improving students' mathematics scores at public examinations and measures they can implement at the classroom level by themselves, interacting with other teachers and with the support from relevant authorities. It is heartening to see that some schools and teachers implementing school-based strategies to enhance students' achievements in mathematics despite the lack of appropriate resources. Moreover, some teachers seem to have already recognised the need to collaborate with other teachers.

4.2.7 Teachers Classroom practices –The analysis of classroom observations

The instruments used for observing the classrooms had six dimensions as listed in the Table below.

A standardized average of each subscale was calculated for classrooms separately, by dividing the sum of scores given to each indicator in the scale by the product of number of indicators and response categories. Table 4-26 indicates the results of this analysis.

Table 4.26 Standardised average of the scale scores as a percentage

Quality Standards (Six scales)	Percentage (%) N = 49
Efficient Classroom Management	62.37
Safe and Stimulating learning environment	56.34
Clear Instructions	62.31
Adaptation of teaching	49.23
Teaching learning strategies	51.36
Involvement of pupils	62.24

According to Table 4-26, approximately 62% of teachers indicated 'efficient classroom management, clear instructions, and proper involvement of pupils while 49-56% of teachers indicated adaptation of teaching, teaching learning strategies and providing safe and stimulating learning environment. All six standards need substantial improvements while the above mentioned three standards require special attention. To identify relative strengths and weaknesses of mathematics teachers' classroom practices we compared the mean values of scores of different indicators belonging to each of the six standards (sub-scales).

Figure 4.25 indicates that only 5 indicators reached a mean score of 2.7-3.0. According to the measurement key of the observational schedule, a score of 3 means there are more strengths than weaknesses. Figure 4.25 indicates that only one indicator, namely 'Evaluates whether the objectives have been achieved at the end of the lesson,' reached the score of 3.0. The five indicators that reached 2.7-2.8 are,

- Ensures orderly progression of the lesson
- Supports the self-confidence of the students.
- Respects for the students in language and behaviour

- Clarifies lesson objectives at the beginning of the lesson
- Gives clear instructions and explanations.

Seven other important indicators scored 2.1 or below indicating more weaknesses than strengths. Among them were,

- Ensures the teaching materials are oriented towards transfer
- Adapts the assignments and processing to the relevant differences between students
- Adapts the instructional strategies to the relevant differences between students
- Promotes mutual respect,
- Promotes cooperation between students,
- Makes use of teaching strategies that activate students
- Ensures the use of control activities
- Stimulates independence of study

According to the above analysis teachers' classroom practices are stronger in delivering an orderly lesson but weaker in classroom management, enhancing collaboration among students, making use of adaptive teaching strategies, promoting students' active learning, use of metacognitive strategies and creativity.

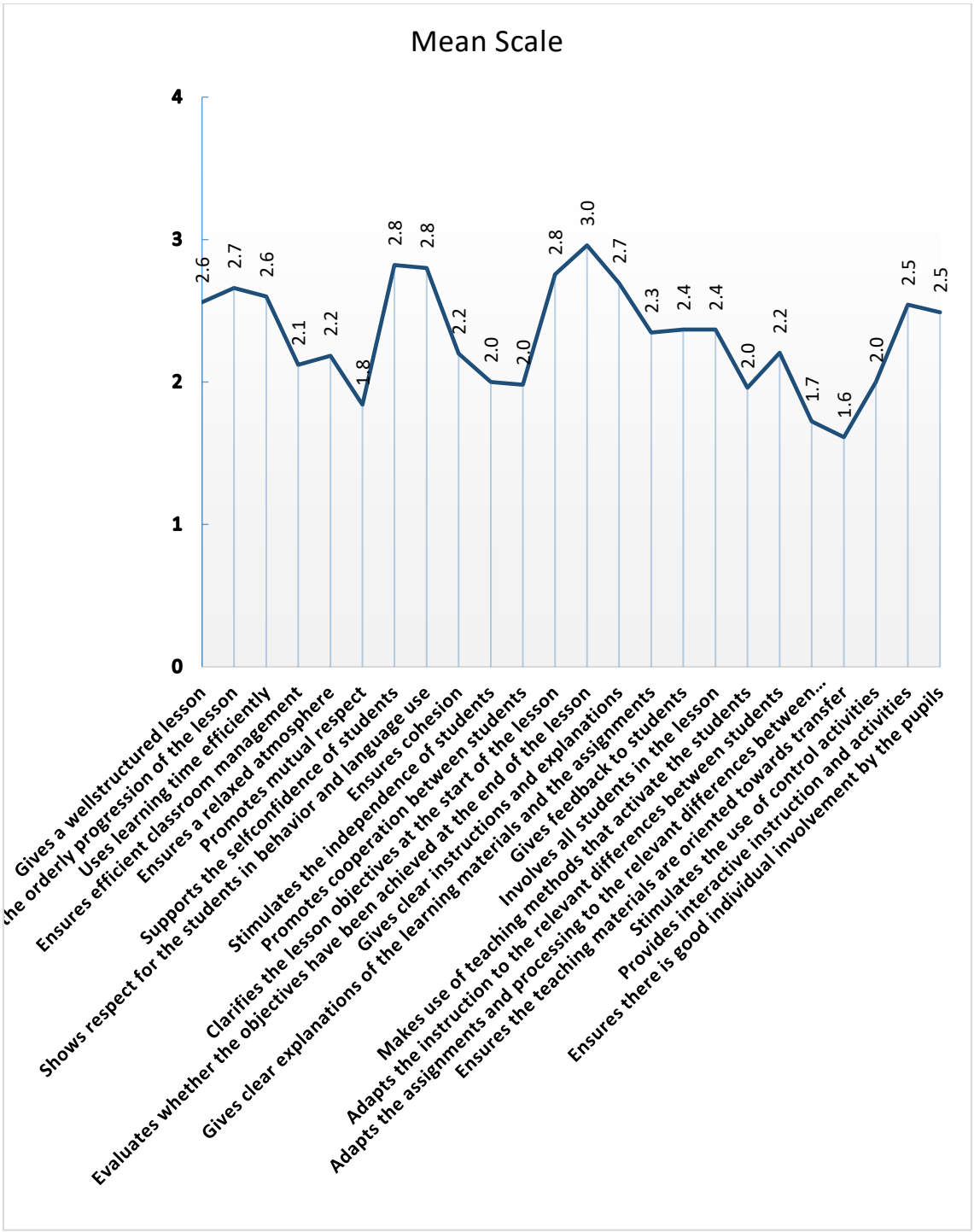

Figure 4. 26 Mean values of classroom practices indicators

Rating key: 1- Predominantly weak, 2-more weaknesses than strengths 3- more strengths than weaknesses, 4- predominantly strong

Qualitative data analysis conducted with the data collected through semi-structured observation revealed comparable patterns of classroom practices as follows:

- Majority of lessons followed a traditional format which included:

- An introduction -> Teacher modelling -> Student Individual Practices -> monitoring by the teacher -> Feedback and further practice -> Homework
- Others rarely included, group activities, games, individual and group assignments, guided discovery
- Classroom Management was an issue in some classes.
- Teachers did not pay attention to the students who needs additional support for learning in some of the classrooms.

Chapter 5:
Discussion of findings, Recommendations, and Conclusion

5.0 Introduction

In the phase one of this study, we have focused on identifying the current situation of mathematics education in the Central province of Sri Lanka using descriptive survey research methodology. In the previous chapters we explained the background and rationale for the current study, reviewed related literature, described the methodology adopted, analysed the data, and summarized the findings. In the current chapter our purpose is to discuss our key findings in relation to the following three research questions of the Phase 1 of the study and to highlight the implications of these findings to policy practice and research in mathematics education.

1. What is the existing situation of mathematics education at the junior secondary level in the selected province?
2. What are the key factors affecting teaching, learning and achievements in mathematics at distinct levels?
3. What interventions are necessary at distinct levels of the education system to improve teaching and learning for instilling skills of 21st century among students?

5.1 Discussion of findings

In this section, we discuss findings in relation to the above research questions and related literature.

5.1.1 What is the existing situation of mathematics education at the junior secondary level in the selected province?

Here, we have focused on students' achievements, human resources available for teaching and learning mathematics at the junior secondary level. Accordingly, we have found that:

1. **Students in the sample recorded low achievements in mathematics.** Grade 7 students' achievement (Mean=29.3, SD= 21.8) in the sample were well below the mean score of Grade 8 students (48.89) of the National assessment by NEREC (2016).

Approximately 73% of students scored below 40 marks and 22% of students scored 0-10 marks.

2. **There were significant differences in mathematics achievements among schools according to the Grade type and ethnic type**. Type 1C schools showed better achievements than Type 1AB and Type 2 schools. Sinhala Schools showed better achievements than Muslim and Tamil schools.

3. **The sample of mathematics teachers were heterogeneous in terms of their academic and professional qualifications.** Most of the mathematics teachers (66%) have G.C.E. (O/L) and G.C.E. (A/L) qualifications while 34% of mathematics teachers are degree holders. Out of them, only 16% of teachers have offered mathematics as a subject in their first degree. In the sample of 50 teachers, 78% of teachers had professional qualifications while 22% did not have any professional qualification in teaching.

5.1.2 What are the key factors affecting teaching, learning and achievements in mathematics at distinct levels?

Data collected from teachers, and students through questionnaires and interviews were used to identify these factors.

Six types of factors have been emerged in the analysis. They were.

1. Student related factors,
2. Teacher related factors
3. Teachers' classroom practices
4. Parents and Home environment related factors
5. School and school administration related factors
6. Curriculum and In-service teacher training related factors

5.1.2.1 Student related factors

1. **Students' absenteeism is high**. Only 70% of students attended regularly by getting absent for less than one day per month.

2. **Majority of students (65%) participated in paid tuition classes.** Students participated in tuition classes to excel in mathematics classrooms (30%) and to improve their learning in mathematics classroom (35%). Students and their parents seem to have considered that additional instruction is necessary for most students to excel in mathematics and/or to improve their learning.

3. **Students' aspirations are high:** The enumerators had to explain the diverse types of qualifications such as diploma, degree and postgraduate qualifications listed in the students' questionnaire to get the responses for the relevant question in the questionnaire. Students reported elevated level of aspirations where 80% of students reported that they expect to achieve 1st degree or postgraduate degree level qualifications while 4.4 % of students reported that they want to achieve up to G.C.E. Ordinary Level qualifications. Girls reported significantly higher aspirations than boys. Students in Type 1AB and 1C schools also reported significantly higher aspirations than the students in type 2 schools.

4. **Students indicated both intrinsic and extrinsic motivations towards mathematics**

   The questionnaire included TIMSS 2011 scales about three motivational constructs: intrinsic value (interest), utility value, and ability beliefs. Intrinsic value refers to doing an activity because it is interesting or enjoyable. In contrast, extrinsic motivation refers to doing something because it leads to a desired outcome. There are many types of external motivation from teacher praise to good grades, to being accepted to a good university, to having a successful career and daily life.

   They seem to have realised its intrinsic value because they believed Mathematics will help them: to learn other school subjects (88.3%); to get ahead in the world (93.3%) etc. Students also valued learning mathematics for its extrinsic value: their daily life (93.9%); to enter higher education (93.1%); to get the jobs that they want (88.2%); (95%) their parents expect that it is important to do well in Mathematics; to do well in Mathematics to get a job that they want to do (88%); learning Mathematics will give them more job opportunities in their future (73.8 %).

5. **Students reported mixed feelings and attitudes towards mathematics.**

   The 'Students like Learning Mathematics scale' (TIMSS 2011) is used to measure students' interest and liking of learning mathematics.

   Ninety one percent reported that they enjoy learning Mathematics. However, 26-33% reported that Mathematics is boring, and they wish that they did not have to study Mathematics. It is not clear why does18-25% of the students respond positively to the contrasting statements that indicated positive and negative attitudes towards mathematics.

   Most students (92%) indicated that they are confident and doing well in mathematics. At the same time 40% students reported that mathematics is harder for them and 47% indicated that mathematics is more difficult for them than for many of their classmates. Thirty five percent of students indicated that mathematics makes them nervous or confused.

6. **Most students participated in private tuition in mathematics to excel in class or to receive additional support for learning.**

   Most parents and students value tuition classes as an additional support for students' mathematics learning. About 65% of the students participated in paid tuition classes out of which 30% indicated that they participate in tuition classes to become an expert in class and 35.2% their participation to better learn in class. There was a significance difference in student's participation in tuitions classes by ethnicity (p= 0.000) and school type (p=0.000). There was no significant difference in participating in tuition classes by gender (p=0.231).

7. **Student related limitations affecting teaching and learning**

   A small percentage of teachers indicated that students in the selected classroom are always lacking prerequisite knowledge or skill (8%), suffering from lack of basic nutrition (8%), suffering from not enough sleep (6%), disruptive students (4%), uninterested students (8%), students with physical disabilities (6%) and students with mental, emotional, or psychological disabilities (6%). However, 32%-50% of the teachers reported that students sometimes show the above stated limitations when teaching mathematics in the classroom. School based approaches seem necessary to address these context-based issues that affect different teachers in different schools.

According to Kele & Sharma (2014) learning mathematics does not only involve thinking and reasoning, but it is also dependent on the attitudes of the learners towards learning and mathematics. Students' dislike for mathematics and fear of mathematics or mathematics anxiety which is defined as unpleasant feelings of tension or fear when doing mathematics (Ma & Xu, 2004) has a detrimental effect on mathematics-related affect and performance (Whyte and Anthony,2012; Morsanyi, Busdraghi, & Primi, 2014; Bandaranayeke and Turner, 2018).

Mullis et al (2012) also indicate that students' lack of prior knowledge and skills affect their mathematics achievements. The importance of prior knowledge in learning new things is highlighted in cognitive and constructive theories of learning. "Every new thing that a person learns must be attached to what the person already knows" (McLaughlin et al., 2005, p. 5).

Above findings indicate that to improve students' learning in mathematics teachers, need to address problems faced by the students with the support from the schools, teacher education and professional development programmes and higher authorities.

5.1.2.2 Teacher related factors

1. Heterogeneity of Mathematics teachers' characteristics

Mathematics teacher sample was heterogeneous in terms of their gender, academic qualifications, professional qualifications, and years of experience. The analysis of teacher qualifications revealed that there is a lack of qualified teachers to teach mathematics at the junior secondary level.

- **Teachers' gender, age, and years of experience**

Majority of mathematics teachers are females (61%). Most of the teachers (64%) are also less than 40 years old. A great proportion of mathematics teachers (44%) in the sample have less than 5 years of experience, 12% have between 5-10 years of experience and the rest (44%) have more than 10 years of experience.

- **Teachers' Educational and Professional qualifications**

Most of the mathematics teachers (66%) have G.C.E. (O/L) and G.C.E. (A/L) qualifications while 34% of mathematics teachers have degree qualifications. Out of them, only 16% of teachers have offered mathematics as a subject in their first degree. Of the G.C.E. (A/L) qualified teachers only 38% studied mathematics for their G.C.E. (A.L.). Altogether there were 54% teachers who studied mathematics up to GCE (A/L) or first-degree level. Majority of mathematics teachers have professional qualifications (78%) in the form of a trained teacher certificate, National Diploma in Teaching, Bachelor of Education (BEd) or a Postgraduate Diploma in Education while 22% did not have any professional qualification in teaching.

Research indicate that teachers' mathematics knowledge affects students' achievements. For instance, Charalambous et al (2020) reports that teacher mathematics knowledge positively predicts student achievement gains, and therefore, it is necessary in future to recruit mathematics teachers based on their highest qualification in mathematics, improve professional development opportunities, and to implement CPD programmes to improve existing teachers' mathematical knowledge.

2. Professional satisfaction is high.

Most of the teachers in the selected sample is satisfied about their profession. More than 90% of teachers indicated that they were very often and often satisfied about: their profession as a teacher, being a teacher in the current school; find their work full of meaning and purpose; enthusiastic about the profession; inspired by their work; proud of the work they do or about continuing teaching for as long as they can. All items in this subscale except the item on 'being a teacher in the current school' indicated remarkably high percentages of satisfaction about the profession.

3. Teachers' understanding of the objectives of teaching mathematics need improvement

Most of the mathematics teachers in the selected sample emphasised the objectives stated in the questionnaire. Sixty four percent of teachers heavily emphasised increasing student interest in mathematics. However, some of the mathematics teachers did not heavily emphasise more important objectives of learning mathematical algorithms/ procedures (22%), developing students' computational skills (18%), learning how to solve problems (36%), learning about the history and nature of mathematics (30%), learning to explain ideas in mathematics effectively (30%) and learning how to apply mathematics in business and industry (32%). These findings imply that there is a need to improve teachers understanding of the objectives of teaching mathematics.

4. Teachers reported high level of self-efficacy beliefs in teaching mathematics

Most teachers indicate a very high-level of self-efficacy beliefs in mathematics teaching. Mathematics teachers indicated that they are: able to inspire students to learn mathematics (88%); showing students a variety of problem-solving strategies (94%), providing challenging tasks for the highest achieving students (88%), adapting their teaching to engage students' interest (82%), helping students appreciate the values of learning mathematics (96%), assessing student comprehension of mathematics (88%), improving understanding of struggling students (80%), making mathematics relevant to students (88%) and developing students' higher order thinking skills (82%).

The above teacher related factors indicate following important implications for improving student learning and achievements in mathematics.

- Recruitment of mathematics teachers need to be streamlined. Candidates with higher qualifications in mathematics and with professional qualifications should be recruited to fill the cadre requirements of mathematics teachers at school level.

- Teachers understanding of principles and objectives of mathematics teaching need to be improved. Teacher education and professional development programmes should provide opportunities for the trainees to learn strategies for providing challenging tasks for the highest achieving students, adapting their teaching to engage students' interest, assessing student comprehension of mathematics, improving understanding of struggling students, making mathematics relevant to students, and developing students' higher order thinking skills.

Interventions are necessary at the central, provincial, and school levels to address the above issues. CPD and teacher education programmes also need to address the latter issues by improving contents and delivery of such programmes.

5.1.2.3 Classroom practices of mathematics teachers

1. **Teachers seem to believe that their classroom practices need improvements**

   Most mathematics teachers in the selected sample reported that they used best practices of linking new concepts to students' prior knowledge (74%), and encouraging students to express their ideas in class in every or almost every lesson (60%) while only 34%-44% teachers used the rest of the best practices of relating lessons to students' daily lives (34%), asking students to explain their answers (44%), asking students to complete challenging exercises that require them to go beyond the instructions (38%), encouraging classroom discussions among students (42%), asking students to decide their own problem solving procedures (40%) in every or almost every lesson. Two to four percent of teachers reported that they did not use above strategies when teaching mathematics to the classroom.

   These findings imply that there is a need to improve teachers' understanding of the principles of teaching mathematics (NCTM, 2009) and to equip them with related teaching skills and strategies.

2. **Teachers' assessment practices also need to improve**

   Most teachers used assessments to monitor students' progress in mathematics. Teachers reported that they place major emphasis on the assessment of students' ongoing work (78%), classroom test (58%) and state or district achievement tests (32%). However, it is not clear how the teachers use assessment data for improving student learning in this context. Black and William (1998) postulate that when assessment system integrated with teaching and learning, the effectiveness of teaching and learning becomes visible through students' substantial learning gains (Black & William 1998). Therefore, we can infer that teachers' assessment practices in mathematics needs further investigation and improvement.

3. **Teachers provide homework regularly but provide feedback less frequently.**

   About 97% of students agreed that teacher's give homework and assignments on a regular basis where 62.4% indicates that this is happening every day. Most teachers also reported that they always or almost always give students homework. There were differences in how they did use homework to reinforce and improve student learning. Only 60% of teacher's corrected assignments and gave feedback to students, 48% discussed the homework in class and 82% monitored always or almost always whether the students completed the homework. A small percentage of teachers used homework marks in grading students. Teachers' use of homework for reinforcing and improving students' learning needs improvement.

4. **Most students evaluated teachers' teaching positively while others indicated that teaching strategies need improvements.**

Eighty four percent of students evaluated teacher's teaching behaviours and interaction with the students positively. About 14% of students indicated that they did not know what their teacher expected them to do, and 11% students indicated that they disagree with the statement that 'My teacher gives me interesting things to do'. These students' responses indicate that teaching strategies need improvements.

The above findings from the analysis of questionnaire data and interview data clearly indicate that teachers need to improve their classroom practices in relation to many aspects. The analysis of observational data further elaborated the strengths and weaknesses of mathematics teachers' classroom practices.

5. **Teachers' classroom practices need improvements in all dimensions.**

According to the analysis of classroom observation data, approximately 62% of teachers scored good in 'efficient classroom management, and clear instructions, while 49-56% of teachers scored good in adaptation of teaching, teaching learning strategies and providing safe and stimulating learning environment. These results implicate that all five standards need substantial improvements while latter three standards require special attention.

Further analysis of indicators of best practices relevant to the above standards revealed that teachers' classroom practices are stronger in delivering an orderly lesson but weaker in classroom management, making use of adaptive teaching strategies, and enhancing collaboration among students, promoting students' active learning, use of metacognitive strategies and creativity. Teachers' current practices do not appear to be geared towards improving 21st century learning and innovation skills and metacognition.

Qualitative analysis confirmed and further elaborated above findings highlighting following weaknesses.

- Majority of lessons followed a traditional teacher centred format.
- Most lessons rarely included group activities, games, individual and group assignments, and guided discovery that allow students opportunities for peer interactions and learning, self-learning, collaborative learning, critical thinking, creativity, problem-solving and communication.
- Classroom Management was an issue in some classes where teachers ignored distracted and disengaged students.

- Many teachers did not pay attention to the students who need additional support for learning.

Above findings suggest that many students who perform poorly in achievement tests do not receive attention of the teachers in mathematics classrooms and students get minimal opportunities for active learning and to improve 21st century skills such as metacognition, communication, collaboration, critical thinking, and creativity.

Moreover, the comparison of teachers' beliefs about their classroom practices and their observed classroom practices indicates that they are incongruent with each other. Cross Francis et al (2015), after reviewing research on the relationship between teachers' math-related beliefs and instructions infer that math-related beliefs are not always the key factors or core beliefs influencing instruction. Issues in the school context that are so inescapable can dominate teacher's instructional decision making. Therefore, Cross Francis et al (2015) suggest the researchers to focus on identifying the key factors that drive teachers' actions and provide usable knowledge for teacher educators and professional developers to support their work with teachers. Findings reported in 5.1.2.4 to 5.1.2.6 indicate the contextual issues affecting teaching learning process in the selected sample of schools.

The above findings on teachers' observed classroom practices and teacher beliefs have many implications for initial and continuing teacher education and professional development programmes.

5.1.2.4 School and school administration related factors

Factors related to school, included the lack of human and physical resources, and teacher's workload.

1. **Academic climate in the school and the support received by teachers**

Schools are good in implementing the school curriculum.

Most teachers (65%-80%) reported that their schools are good in implementing the school curriculum. The teachers rated that teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school curriculum, teachers' expectations for students' achievement, working together to improve student achievement and teachers' ability to inspire students as very high or high.

Teachers were less confident about student learning and behaviour.

However, teachers indicated that they were less confident about student learning and behaviour. Most of the teachers (20% -22%) rated: students desire to do well in the school; students' ability to do well in the school and students' ability to reach school's academic goals as low, or very low. Meanwhile, (60%) of teachers rated students' respect for classmates who excel in the school is low or very low. Mathematics teachers appear to be less confident about their students' motivations and ability to learn mathematics.

Teachers (42% or more) reported that they do not receive adequate support from the school leadership for teaching and professional development

Teachers rated, clarity of the school's educational objectives (46%), the collaboration between school leadership and teachers to plan instruction (42%), amount of instructional support provided to teachers by school leadership (42%) and school leadership's support for teachers' professional development (48%) as low or very low (minimal). Many teachers appear to believe that school goals are not clear enough and they do not receive adequate support from the school leadership for teaching and professional development.

2. Physical facilities for teaching are not at a satisfactory level

Most teachers reported that facilities for teaching in the classroom was not at a satisfactory level. According to the teachers' responses: 56% of teachers do not have adequate workspace, 64% teachers do not have adequate instructional materials and supplies, 82% of the school classrooms are not cleaned often enough and the (58%) of school classrooms need maintenance work. Forty percent of the teachers do not have adequate technological resources and 46% of the teachers do not have adequate support for using technology. These findings imply that improvement of physical facilities including technological resources for mathematics teaching needs to be a priority at provincial and zonal levels.

3. Professional interactions with other teachers do not happen very often

Teachers indicated that professional interactions with other teachers does not happen very often. Sharing teaching experiences, work together to try out new ideas, work as a group on implementing the curriculum and work with teachers from other grades to ensure continuity in learning, collaborating in planning and preparing instructional materials, visiting another classroom to learn more about teaching are reported as happening very often among approximately 20% or less teachers in the selected sample. Zonal and school level interventions are necessary to address these issues.

4. Workload is remarkably high and working conditions are not satisfactory

The workload of the mathematics teachers in the selected sample is at a quite an elevated level. Teachers reported that; there are too many students in the classroom (22%), I have too much material to cover in this class (24%), I have too many teaching hours (30%) and I need more time to assist individual students (54%).

Teachers in some schools are affected by the substantial number of students in their classrooms, too many teaching hours, and the lack of time to assist students individually. Some of the teachers were also not happy about the working conditions due to parental pressure, frequent curricular changes, excessive administrative tasks, cocurricular activities and inadequate support from school administration.

In addition to the above, issues related to heavy workload, the lack of qualified teachers to teach mathematics (teachers without professional qualifications and teachers specialised in other subjects were teaching mathematics in many schools) and the lack of enough facilities and materials also surmised in the qualitative analysis of teacher interviews. These findings have implications for central, provincial zonal and school level interventions.

Research indicates that school related factors affect students' mathematics achievements. According to Chiu (2010) inequality and school characteristics were linked to student achievement, where equal distribution of country and school resources were linked to higher mathematics scores. Mullis et al (2012) also observed that poor working conditions of teachers affect students' achievements in Mathematics.

5.1.2.5 Factors related to curriculum and Inservice training

1. Curriculum related factors

Teachers in their interviews, attributed complexity of the curriculum, content overload in the curriculum, lack of gradual progression over the grade levels as well as the lack of supplementary curriculum materials as reasons for students' low achievements.

According to Schoenfeld (2002) high quality curriculum is essential in improving students' achievements in mathematics. Sri Lankan mathematics curricula at the secondary level are based on the standards specified by the National Council for Teachers in Mathematics (NCTM) which are considered as international benchmarks in mathematics education (McCaul, 2007). According to McCaul,2007) process standards are not sufficiently addressed in the mathematics curricula at the junior secondary level. Learning outcomes and measures to achieve learning outcomes in relation to the process standards are not sufficiently elaborated in the secondary level mathematics curricula. Egodawatte (2014) also affirms that competency-based mathematics curriculum of Sri Lanka which is introduced in 2007 (later revised in 2015) has not fulfilled its objectives as a competency-based curriculum.

Therefore, the teachers' views need further investigation and suitable remedial measures should be implemented by the curriculum developers. As indicated in the review of literature in this report, 21st Century learning and innovation skills are not incorporated into the junior secondary mathematics curricula.

2. The focus of in-service teacher training is mostly on mathematical content and curriculum

Teachers indicated that most of the in-service teacher programmes very often focused on mathematics content (48%), mathematics pedagogy/ instructions (34%) and mathematics curriculum (40%). These training programmes were less frequently focused on, integrating information technology into mathematics (20%), improving students' critical thinking or problem-solving skills (22%), mathematics assessment (22%) and addressing individual students' needs (30%).

These findings imply that in-service mathematics teacher training programmes organised at zonal and provincial levels need to be more focused on pedagogy, improving students' thinking and problem-solving skills, assessments and addressing students' needs.

5.1.2.6 Parental and home related factors

Seventy percent of households had less than 25 books. About 28% of the households had 26 to 200 books. Thus, indicating that most students lacked enough books for reading at home.

Parental expectations and support

Teachers rated parental expectations and their support to students' education as minimal. All the items under this scale showed low percentage values in the very high and high categories: parental involvement in the school activities (24%); parental commitment to ensure that students are ready to learn (10%); parental expectations for students' achievement (34%); parental support for students' achievement (7%); and parental pressure for the school to maintain high academic standards (10%). Teachers in most schools reported that they receive less parental involvement and commitment. Parental support and expectations for students' achievements were also rated as low or very low by most teachers

Support from home

Only 50.40% of students always receive support from home for learning mathematics while 43.3% indicate that they receive support sometime. Nearly 4.9% of students never received support from home.

Research consistently shows a strong positive relationship between achievement and socioeconomic indicators such as parents' or caregivers' level of education or occupation, facilities at home environment and parental attitudes towards education (Mullis et al, 2012; Alghazo & Alghazo, 2015; Lamb and Fullarton, 2015).

5.2 Recommendations

What interventions are necessary at distinct levels of the education system to improve teaching and learning for instilling skills of 21st century among students?

In this study we tried to understand the existing situation of mathematics education in the junior secondary level of education in the Central province using both quantitative and qualitative data collected from schools, principals, teachers, and students. Our findings discussed in the above section signify that,

1. student learning and achievements in mathematics in the selected province is affected by complex interaction of many factors related to central, provincial, school and classroom levels as well as, students, teachers, parents, and home environments.

2. Teachers' classroom practices need to be improved in relation to effective classroom management, teaching learning strategies, providing safe and stimulating learning environment and adaptive teaching. There is a mismatch between teacher beliefs and their classroom practices, and this could be a result of contextual factors affecting mathematics teachers.

3. Improvement of student learning and teachers teaching should be given priority and to achieve this purpose a multilevel approach that incorporate National, Provincial, Zonal, and school level policies and strategies is necessary.

4. Teachers should be empowered to become inquirers, who identify problems related to teaching and learning mathematics in their classrooms, and strategies necessary to address such problems, implement those strategies, monitor, and evaluate their effects on students' progress and take remedial action. Facilitation of the development of professional learning communities at school and zonal levels is necessary.

Based on the above findings we present the following recommendations, which are necessary to implement by the teachers, schools, teacher education and professional development programmes, and National, Provincial, and Zonal education authorities.

1. **Teachers:**

At classroom level teachers may have to use strategies to improve student learning and achievements by focusing on the following.

a. Improve students' daily attendance.

b. Reduce bullying and misconduct towards peers by promoting students' self-discipline.

c. Improve student motivation by using more student-centered approaches, relating mathematics to daily life, and using more stimulating and interesting teaching strategies and teaching learning materials.

d. Make mathematics learning enjoyable by setting interesting tasks.

e. Facilitate interactive learning by providing opportunities to students to communicate mathematical ideas in the classroom, to ask questions and clarify their solutions.

f. Improve students' problem-solving abilities and active learning through teaching metacognitive strategies, and using collaborative learning, inquiry, project, game based and problem-based learning in mathematics classrooms. Use of these strategies also facilitates the development of 21st century competencies among students.

g. Use scaffolding and provide differentiated learning opportunities to facilitate all students to achieve stipulated learning outcomes.

h. Use multi-level teaching strategies and scaffolding to cater to the needs of students with diverse ability levels.

i. Use dynamic assessment, authentic assessment and ipsative assessments and formative assessments to improve students' learning.

j. Use assessment data to provide feedback to students and parents and for remediation and improving students' mathematics self-efficacy beliefs.

k. Use creative strategies to reduce students' fear of mathematics by setting appropriate tasks for such students to achieve success and receive reinforcements.

l. Improve opportunities for co-curricular activities in mathematics.

2. Teacher Education and Professional Development Programmes

To implement the above strategies, teachers need continued support from organisations responsible for teacher education and professional development, school management, Zonal, Provincial and Central level educational authorities.

Accordingly, teacher education and professional development programmes need to pay attention to the following:

a. Provide opportunities for teachers who lack adequate knowledge in mathematics/pedagogy, to enhance their mathematics knowledge and pedagogical competence.

b. Improve awareness of teachers on the principles, objectives, and standards of teaching mathematics.

c. Enhance teachers' ability to set interesting mathematical tasks for students by modifying regular tasks in textbooks.

d. Develop teachers' capacity for effective classroom management and the use of 21st century skills of communication, collaboration, critical thinking and problem solving, creativity, and metacognition in improving student learning and achievements.

e. Increase teachers' knowledge and skills of using teaching strategies that promote active learning and transfer of learning.

f. Improve teachers' capacity to identify students who need additional support from teachers and to use scaffolding and other supportive measures to improve learning.

g. Develop teacher capabilities in using a variety of assessment methods including ipsative assessment for improving self-efficacy beliefs and growth mindset among learners, and dynamic assessment, authentic assessment, and formative assessment to improve learning.

h. Improve capacity of teachers to use assessment data to provide feedback to students and parents and for remediation and improving students' mathematics self-efficacy beliefs.

i. Develop the capacity of teachers to conduct classroom-based action research studies to solve problems that they encounter in teaching and learning process.

3. Principals and Schools

Principals and school management need to provide mathematics teachers:

a. Opportunities to identify/ be aware of school's curricular goals.

b. Opportunities to interact with other teachers to improve students' learning and achievements.

c. Adequate support for instructional planning, teaching, organising co-curricular activities, and professional development,

d. Support to maintain clean and stimulating learning environments in mathematics classrooms, and in the school.

e. Facilitate the use of ICT and stimulating teaching learning materials in the mathematics classrooms.

f. Provide opportunities for mathematics teachers to interact and collaborate with other teachers to enhance their professional learning by engaging in professional learning communities through SBPTD activities such as Lesson Study, collaborative or Classroom-Based Action Research (CBAR) and classroom visits.

g. Opportunities to meet parents to provide feedback on their children's progress and to get parental support for improving students learning.

4. Provincial and zonal level authorities

Provincial and zonal level authorities need to,

a. Monitor and evaluate teaching, learning and assessment practices and students' achievements at school level and implement remedial measures to ensure all learners reach level appropriate mathematical competences at the end of each cycle of education.

b. Facilitate the development of professional learning communities by encouraging Collaborative Action Research (CAR), CBAR and lesson study programmes at school, zonal and provincial levels to enhance mathematics learning and incorporating 21st century competences in the teaching learning process.

c. Identify professional development needs of mathematics teachers and develop and implement appropriate in-service training programmes.

d. Mobilise officers and ISAs responsible for mathematics education to provide necessary support to teachers to improve their pedagogical practices by engaging in co-teaching and other relevant practices such as CAR and lesson study.

e. Provide adequate physical and human resources to all schools for effective teaching and learning in mathematics.

f. Provide digital infrastructure for all schools to facilitate ICT integrated mathematics learning.

g. Develop and implement mathematics education development projects at the provincial, zonal, and school levels.

5. National level

At national level, by the NEC, NIE and the MoE, it is necessary

a. To formulate a policy framework and a national strategy for school level mathematics education in the 21st century.

b. To develop a curriculum framework for incorporating 21st century competences to teaching and learning mathematics at school level.

c. To reform mathematics curricula, teaching learning and assessment practices to facilitate all students to achieve level appropriate mathematical competences at the end of each cycle of education.

d. To streamline mathematics teacher recruitment, deployment and, teacher development procedures by adopting appropriate national and provincial level policies.

e. To provide appropriate human and physical resources to all schools on a norm-based approach for effective mathematics teaching and learning,

f. To provide digital infrastructure to all schools and equitable access to digital resources in mathematics to all mathematics teachers and learners.

g. Reform teacher education and professional development programmes at all levels to enhance teacher quality and 21st century professional competences.

h. Monitor and evaluate mathematics teaching and learning at distinct levels and implement remedial measures to ensure that all learners master the level appropriate competences at the end of each cycle of education.

5.3 Implications for further research

The purpose of this diagnostic study was to identify key factors affecting mathematics teaching and learning at the junior secondary level classroom in the Central province of Sri Lanka. In this process we have been able to specify many recommendations to be implemented at distinct levels of the education system. As researchers and teacher educators we have also been able to develop insights on the possible ways of influencing teacher beliefs and practices to improving student learning in mathematics classrooms. For this purpose, we have decided to use a Collaborative Action Research (CAR) approach in the phase 2 of this study. The first step in this process was to conduct a dissemination seminar to sensitise the relevant authorities at Provincial, Zonal, and School level and mathematics teachers about the current situation of mathematics education in the province. We have conducted the dissemination seminar in February 2020 and 25 officers, ISAs and teachers consented to work with us in the CAR phase of the study which will be described in a separate volume.

5.4 Conclusion

Student achievements in Mathematics need a lot of improvements since seventy percent of students score below 40 marks. Students expressed mixed feelings about learning mathematics. More than 95% say that they like mathematics and 35%-40% say that they fear mathematics, mathematics is boring, or mathematics make them confused. This situation is a result of complex interaction of many factors related to teachers, students and classroom practices, schools, and parents that affect mathematics teaching, learning, and achievements. These factors need to be addressed at multiple levels from the national level to the classroom level and to the individual level of students.

There are many issues to be addressed at classroom level by teachers. Teachers need to change their practices related to classroom management, teaching, learning and assessments. For this purpose, teachers need support from parents, other teachers, principals, teacher education and professional development programmes, and educational authorities at distinct levels. In this document we have made many suggestions to be implemented at distinct levels and finally, we iterate the need to use a tri-level approach to reforming mathematics education at the junior secondary level where schools, provincial and national level authorities work together and support mathematics teachers to bring about change at classroom level.

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