## Chapter 1

# An Exploratory Study on Low Attainers in Primary Mathematics (LAPM)

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This introductory chapter provides the background to an exploratory study on Low Attainers in Primary Mathematics (LAPM) which was carried out in Singapore. It provides the rationale for the study and the definition of low attainers that guided the study. It also reviews literature on low attainers in mathematics, and states the research questions which were investigated in the study. Lastly, the method and instruments used for data collection in the study are described.

### 1 Why Study Low Attainers in Primary Mathematics

Ginsburg, Cooke, Leinward, Noell and Pollock (2005) found in their secondary analysis of the Trends in International Mathematics and Science Study (TIMSS) 2003 data for the US that pupils who were failing at grade 4 continued to fail at grade 8 subsequently. Table 1 shows the TIMSS 2007 mathematics mean score by the percentiles of the participants from the top four performing countries for grade 4 mathematics. From the table it is apparent that grade 4 pupils from Singapore were underachieving, in mathematics, compared to their peers from Hong Kong and Chinese Taipei when comparing their mean scores of up to the $5^{th}$, $10^{th}$, $15^{th}$, and $20^{th}$ percentiles. Such findings from international studies and also national examinations have prompted

researchers and policy makers to explore the needs of and provisions for low attainers in primary schools.

Table 1
*TIMSS 2007 grade 4 mathematics mean scores*

| Country | Rank | TIMSS 2007 Grade 4 mathematics mean scores of pupils up to the $n^{th}$ percentiles | | | | |
|---|---|---|---|---|---|---|
| | n = | $5^{th}$ | $10^{th}$ | $15^{th}$ | $20^{th}$ | $25^{th}$ |
| Hong Kong | 1 | 462 | 488 | 503 | 514 | 524 |
| Singapore | 2 | 408 | 440 | 461 | 477 | 490 |
| Chinese Taipei | 3 | 427 | 453 | 469 | 481 | 490 |
| Japan | 4 | 404 | 432 | 449 | 463 | 474 |

Only a few studies done so far in Singapore provide findings that may relate to low attainers in primary mathematics (Loo & Fong, 1996; Foong, 1999; Lee, 1999; Leong, 1999; Lim, 1999; Ng, 2003). Loo and Fong (1996) found that both mathematical and psychological factors correlated with mathematics achievement while Ng (2003) found that social economic status related variables also correlated with mathematics achievement. Foong (1999) found that low attainers were diverse in their needs and they were heterogeneous. Lim (1999) found that low attainers preferred formally designed learning environments and Lee (1999) noted that academic achievement scores related positively with subject-related self-esteem. Leong (1999) in her study on parental involvement and effects on the academic performance of students found that there was no conclusive evidence to suggest that the higher the degree of parental involvement, the better the academic performance of the student. Though these studies do provide glimpses of the characteristics of low attainers, none of them have investigated the content knowledge of low attainers, their learning experiences and how schools organise, motivate and inspire them.

In Singapore mathematics is a core subject in the school curriculum for primary and secondary education. Failure in mathematics due to factors that may be controlled for would be unjust for the pupils. Therefore this study hopes to shed light on the needs of low attainers in primary mathematics and help them achieve their potential.

## 2 Who are the Low Attainers in Primary Mathematics

Early research on low attainment in mathematics describes low attainers in mathematics to be those pupils outside special schools who fall, for whatever reason, into the bottom 20 per cent of mathematical attainment in their age group in national assessment (Denvir, Stolz, & Brown, 1982). Denvir, et al., (1982) have used the term low attainer to describe the observable performance of a pupil, without implying a cause. Other labels attached to such performing students are slow learners, at risk students, special needs children, less able children and so on. Realising that these labels point towards deficiencies on the part of a learner, Haylock (1991) adopted a pragmatic approach and used the term "low attainers" to define pupils who attain very much less in mathematics when compared to their contemporaries. The use of this term does not make any judgment about the reasons for low attainment in mathematics.

Like Haylock (1991), in this study we too have chosen to adopt a very pragmatic approach by using the term "low attainers" to be all encompassing of what some may label as: less able children, slow learners and under-achievers.

## 3 Review of Literature

Boaler (1997) in her work found that teachers commonly believe that children in low attaining groups are similar. This is contrary to research on low attainers in mathematics which has found that low attainers are heterogeneous (Foong, 1999; Houssart, 2004). Descriptions and explanations of low attaining pupils have tended to emphasise their diversity. For example, Haylock (1991) talks about a broad range of and great variety in differences related to children with low attainment in mathematics. He used case studies of individuals, to demonstrate complex combinations of difficulties in understanding and engagement with mathematics by low attainers. Similarly, Denvir, et al., (1982) also draw on examples to illustrate the diversity of low attainers. Both Haylock (1991) and Denvir, et al. (1982) assert that these children will not form a homogenous group and some of the causes of their low

attainment may be school related while others may not be and hence are beyond the control of the school.

Haylock (1991) in his work suggested that a "*deficit model*" of low attainment that emphasises mainly the diagnosis of the child's difficulties in understanding and mastering mathematics was an inadequate way of analysing the problem. He proposed the "*ecological model*" which attempts to in addition describe the relationships between the child and the whole learning environment to be a better one as it is more likely to produce useful insights. According to Haylock (1991), at least three factors may be related to low attainment in primary mathematics. The factors are as follows:

- Some significant characteristics of school mathematics, such as
  - accuracy and concentration,
  - a symbolic language,
  - abstract concepts and relationships, etc.
- Some specific intellectual or behavioural characteristics frequently associated with low attainers, such as
  - reading and language problems,
  - perceptual problems (spatial orientation, etc.),
  - social problems,
  - mathematics anxiety, etc.
- Some of the shortcomings in the way the subject is often taught and assessed such as
  - the preoccupation of "completing the syllabuses",
  - meaningless routines,
  - the teacher's way is the only way,
  - practice and yet more practice,
  - assessment tasks are complex and tedious, correlate negatively with motivating for pupils

Mercer and Mercer (2005) stated that pupils failing in mathematics have one or more of the following main difficulties:

- Intellectual problems on the part of the pupil, such as
  - short attention span,
  - low retention (forgets facts and skills),
  - cognitive immaturity,
  - slow in grasping concepts,

- problem in organising knowledge and experience,
- inaccurate computation / procedure,
- lack of verbal, spatial ability.

- Affective, such as
  - negative attitude and low motivation,
  - anxiety / panic,
  - low self-concept.
- Pupil's educational experience in mathematics, such as
  - lack of appropriate background knowledge,
  - inadequate concrete practical experience,
  - symbols too abstract,
  - lack of pre-requisite knowledge,
  - poor mathematical language,
  - use of rules without understanding.

Hence, any combinations of the above may result in low attainment in primary mathematics. Also, Loo and Fong (1996) in their study on variables associated with mathematics achievement of Primary 5 pupils in Singapore found that although both mathematical and psychological factors were related to mathematics achievement, mathematical factors contributed a higher variance to mathematics achievement than psychological factors. In their study mathematical factors comprised logical thinking ability, computational skills, mathematical language, and mathematical concept while psychological factors comprised attitude towards mathematics, interest in mathematics and memory.

Pupils' experiences within school grouping processes and practices are highly significant to their learner identities, their expectations, aspirations and motivations (Dunne, Humphreys, Sebba, Dyson, Gallannaugh, & Muijs, 2007). While prior performance data inform this process, teachers inevitably play a significant part in grouping decisions, which in turn influence their pedagogical approaches with low attainment groups (Kutnick, et al., 2006). In this sense, the organisational structures and processes in schools are highly pertinent to the pedagogical context for low attaining pupils and their teachers.

Attainment grouping in practice appears to advantage some pupils while disadvantage others. Ireson, Hallam, Hack, Clark, and Plewis (2002) found that pupils with high attainment in mathematics benefitted from homogeneous attainment groups while those with low attainment in mathematics benefited from mixed attainment groups. Hallam and Ireson (2007) found that teachers preferred homogenous attainment groups as it allowed pupils to learn at the appropriate level and pace for the group. Slavin (1990) suggested that grouping by attainment increases the motivation of the lower attaining pupils by removing any competition or intimidation from working alongside higher attainers but a later research by Boaler, William, and Brown (2000) does not support this suggestion. The lack of clear evidence to support one form of grouping may reflect the greater influence that other factors have on outcomes such as effectiveness of teaching (Day, Stobart, Sammons, Kington, Gu, Smees, & Mujtaba, 2006) and curriculum offered (Kutnick, Blatchford, & Baines, 2002; Blatchford, Kutnick, Baines, & Galton, 2003)

It is well known that pupils learn more when the school and classroom environments are positive and supportive (Christenson, Ysseldyke, & Thurlow, 1989). The teacher is key, as he or she arranges the physical (seating) and academic (e.g. scheduling, method of lesson presentation, nature of assessment, homework, etc.) variables and establishes the affective nature (e.g. encouragement, competitiveness, and cooperation) of the classroom. Teacher expectations, encouragements, evaluations, attentiveness, and attitudes greatly influence pupils' perceptions of themselves as learners (Mercer & Mercer, 2005). Because many low attainers in primary mathematics have negative perceptions of their ability, teachers must create and maintain a supportive environment. Lee (1999) in her study on low attainers in primary mathematics in Singapore notes that one way to help low attainers is by enhancing their mathematics specific self-esteem through creative and varied teaching strategies.

Sprick (1985) notes that learning is greater and behaviour is more appropriate in classrooms where teachers attend to positive events more than to negative events. Borich (1992) and Brigham, Scruggs, and Mastropieri, (1992) maintain that teacher enthusiasm is an important

aspect of teacher effort, is positively correlated to pupil achievement, and helps establish a positive and supportive learning environment.

Alderman (1990) noted that a positive learning environment and pupil learning are enhanced when teachers believe that all pupils can learn and that teachers can make a difference. It is also equally important to provide the right kinds of learning experiences considering pupil preference for learning styles. Lim (1999) in her study on preferred learning styles of low achieving and high achieving pupils in a Singapore primary school found that low achievers preferred formally designed learning environments. Christenson, et al., (1989) state that a positive learning environment is built upon the use of realistic expectations of pupil learning, the development of instructional plans that consider pupil characteristics and needs, the use of reinforcement for pupil productivity, the use of active monitoring of pupil progress, and the belief that all pupils will experience academic success. Pupils need to be motivated and engaged in the learning process. Often low attainers in mathematics lose their motivation for learning due to repeated failure at mathematics tests. Setting realistic instructional goals and determining mastery criteria are important to pupil motivation. To experience success and link it to one's own effort are critical for the development of motivation in pupils (Alderman, 1990). Hence, opportunities to experience such successes must be available for low attainers in primary mathematics.

From the factors that may be related to low attainment in primary mathematics (Haylock, 1991) and the difficulties that may be experienced by low attainers in mathematics (Mercer & Mercer, 2005), it is apparent that teachers working with low attainers would need customised approaches to help their pupils. Cockburn (1999), notes that difficulties with mathematics may stem from three perspectives: child (experience, expertise, mathematical knowledge and understanding, imagination and creativity, mood, attitude and confidence) task (mathematical complexity, presentational complexity, and translational complexity), and teacher (attitude and confidence, mood, imagination and creativity, knowledge, expertise and experience). There is an abundant of research on how specific causes of low attainment may be

addressed (see Haylock, 1991; Houssart, 2004; Mercer & Mercer, 2005; & Cockburn, 1999).

Following on from the above review of relevant literature, it is apparent that an ecological model would be a preferred one to research the characteristics of low attainers in primary mathematics. The literature also highlights that there are a myriad of factors associated with low attainment in primary mathematics. From the focused discussions the research team held with heads of mathematics departments in primary schools, it was found that teachers do engage their low attainers in remedial lessons. This leads us to infer that there may be a misfit of needs and remediation. Hence an exploratory study of the education of low attainers in primary mathematics that focuses on the characteristics of low attainers and their education, in particular the practices and processes used by schools to identify and organise them, how teachers motivate and inspire them, and how schools and teachers address their diverse learning needs is necessary before any form of intervention strategies can be planned for levelling up the performance of low attainers.

## 4 The Research Questions

The review of literature led to a conceptual framework, shown in Figure 1, which was adopted by the study.

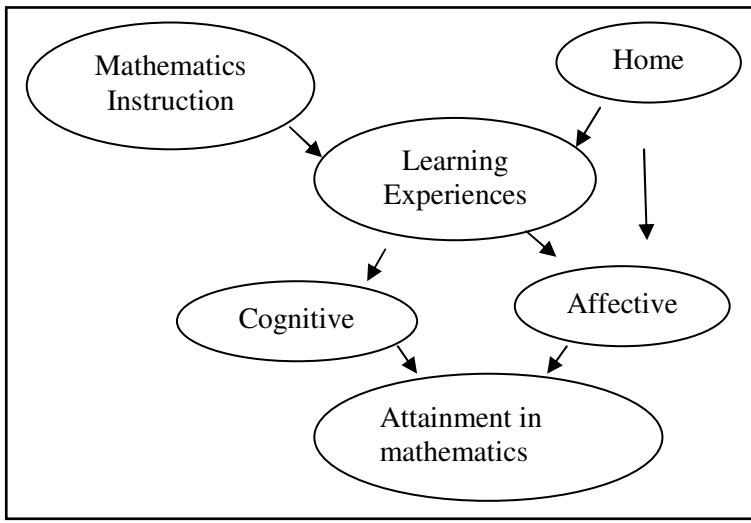


*Figure 1.* Conceptual framework for the study

The framework shows that mathematics instruction and the home impact pupils' learning experiences. These experiences shape pupil's cognitive and affective aspects of learning that inevitable affect their mathematics attainment. Drawing on the framework of the study, six research questions were formulated. The questions are as follows.

1. How did the low attaining pupils perform in mathematics tests that tested mastery of Primary 3 mathematics content knowledge and skills?
2. What were the characteristics of low attaining in mathematics pupils related to school (behaviour during class, absenteeism, interactions with peers), home (support, resources) and self?
3. What were the characteristics of the low attaining in mathematics pupils related to their experiences of learning mathematics?
4. What were the practices and processes used by schools to identify and organise low attainment groups?

5. How did schools and teachers motivate and inspire low attainers in primary mathematics to learn?
6. How did schools and teachers address the diverse learning needs of low attainers in primary mathematics?

In this book, we report the data and findings for only three of the six research questions, which are:

1. How did the low attaining pupils perform in mathematics tests that tested mastery of Primary 3 mathematics content knowledge and skills?
2. What were the characteristics of low attaining in mathematics pupils related to school (behaviour during class, absenteeism, interactions with peers), home (support, resources) and self ?
3. What were the characteristics of the low attaining in mathematics pupils related to their experiences of learning mathematics?

## 5 Method

Both qualitative and quantitative data were collected for the study. Four main methods were used to collect data. They were paper and pencil tests, surveys, interviews and observation. Data were collected from school leaders, heads of mathematics departments, mathematics teachers, pupils and their parents. In accordance with the ethics requirements of the study, consent was sought from all participants.

### 5.1 *The sample*

Nine government schools from across Singapore participated in the study. Participation by the schools was voluntary. The schools identified the pupils for the study, based on the school's criteria of low attainers. The parents of the pupils, identified by the schools, were asked for their consent regarding their child's participation in the study. Pupils' whose parents did not consent were excluded from participation. Pupils whose parents gave consent were asked for their assent. These pupils were the subjects of the study. Table 2 shows the number of pupil participants.

Table 2
*Pupil participants of the study*

| School Code | Location | Number of pupils nominated for the study | Number of pupils with consent from parents | Number of pupils who took all the benchmark tests | Number of pupils who were interviewed |
|---|---|---|---|---|---|
| 01 | East | 37 | 24 | 21 | 23 |
| 02 | East | 69 | 51 | 41 | 48 |
| 03 | East | 43 | 32 | 30 | 29 |
| 04 | East | 33 | 24 | 18 | 22 |
| 05 | East | 78 | 56 | 52 | 55 |
| 06 | West | 52 | 35 | 32 | 31 |
| 07 | North | 74 | 12 | 54 | 11 |
| 08 | West | 55 | 50 | 48 | 45 |
| 09 | West | 119 | 91 | 94 | 82 |
| | Total | 560 | 375 | 390* | 346 |

* This number is larger than the "bona fide participants" of the study as in schools 7 and 9, the teachers administered the benchmark tests to a larger group of pupils in their respective schools.

While the study was in progress, four of the participants left their respective schools. Two went back to their home country and another two transferred to a school that was not in the study. Eventually, the study only managed to interview 346 pupils as 29 pupils were absent on the days of the interviews.

Table 3 shows the number of school leaders and teachers who participated in the study. There were altogether 9 school leaders and 23 teachers who participated. All the teachers were teaching the pupil participants.

Table 3
*School leaders and teacher participants of the study*

| School Code | Location | Number of school leaders | Number of teachers |
|---|---|---|---|
| 01 | East | 1 | 1 |
| 02 | East | 1 | 4 |
| 03 | East | 1 | 1 |
| 04 | East | 1 | 1 |
| 05 | East | 1 | 4 |
| 06 | West | 1 | 4 |
| 07 | North | 1 | 3 |
| 08 | West | 1 | 2 |
| 09 | West | 1 | 3 |
| | Total | 9 | 23 |

Table 4 shows the profile of the teacher participants of the study. More than 75% of the teachers were female. Almost half of the teachers were in the age range of 30 – 39 years, with the rest in equal proportions in the age ranges of less than 30 years and 40 – 49 years. More than 75% of the teachers had less than a year to 10 years of experience of teaching mathematics in primary schools. Almost 15% of the teachers were in their first year of teaching mathematics, i.e. beginning teachers and another 35% had 1 to 3 years of experience of teaching mathematics in a primary school. Only a fifth of the teachers had more than 10 years of teaching mathematics experience in primary schools. Majority (almost 80%) of the teachers had at most three years of experience teaching Primary 3 and / or Primary 4 mathematics. In addition to the three beginning teachers another 7 teachers were also teaching the low attainers for the first time. Majority of the rest (11 in total) had only taught low attainers for at most three years. All the teachers with the exception of one had no formal preparation, i.e. in-service training related to teaching low attainers in primary mathematics.

Table 4
*Profile of teacher participants of the study*

| Attribute | Number of teachers |
|---|---|
| Gender | |
| Male | 5 |
| Female | 18 |
| Age (years) | |
| Less than 30 | 6 |
| 30 – 39 | 11 |
| 40 – 49 | 6 |
| Teaching primary math (years) | |
| Less than 1 | 3 |
| 1 – 3 | 8 |
| 4 – 6 | 1 |
| 7 – 10 | 6 |
| More than 10 | 5 |
| Teaching math to P3/P4 pupils (years) | |
| Less than 1 | 3 |
| 1 – 3 | 15 |
| 4 – 6 | 3 |
| 7 – 10 | 1 |
| More than 10 | 1 |
| Teaching low attainers (years) | |
| Less than 1 | 10 |
| 1 – 3 | 11 |
| More than 4 | 2 |
| Attended in-service training related to teaching low attainers in primary maths | |
| Yes | 1 |
| No | 22 |

## 5.2 *Instruments*

In this section we describe briefly all the instruments that were used to collect data for the study. All the instruments were developed by the research team of the study. In chapters 2, 3 and 4 the instruments used and data collected to answer the three research questions respectively will be detailed.

### 5.2.1 *School management questionnaire*

The School Management Questionnaire was used to gather data from school leaders about the practices used in their schools to identify,

organise, and motivate the low attaining pupils, particularly in mathematics. Appendix A shows the content of the questionnaire.

### 5.2.2 *Teacher profile questionnaire*

The Teacher Profile Questionnaire was used to gather data from the teachers in the study about their qualifications (academic and professional), type of appointment in the teaching profession (teacher, subject head, head of mathematics department, relief teacher, adjunct teacher), their experience in teaching primary mathematics (in terms of number of years), their experience in teaching mathematics to Primary 3 / 4 pupils, their experience teaching low ability pupils (in general), low ability pupils in mathematics, and any specific training related to teaching low attaining pupils. Appendix B shows the teacher profile questionnaire.

### 5.2.3 *Teacher interview prompts*

As part of the study teacher participants were interviewed. The purpose of the interview was to find out teacher's understanding of "low attainers", and their school's practices related to identification, organisation and motivation of low attainers in mathematics. It also sought information on practices specific to the teacher. The interview was guided by the prompts shown in Appendix C.

### 5.2.4 *Benchmark mathematics test*

The eight benchmark paper and pencil mathematics tests were used to benchmark the performance of the pupil participants in mathematics. These tests are described in detail in chapter 2 of the book. Appendices D1–D5 show the tests.

### 5.2.5 *Pupil profile questionnaire*

The Pupil Profile Questionnaire was used to gather data from the pupils about their background such as, race, dwelling, education and occupation

of parents, language spoken at home, availability of study desk, time spent on homework, help with homework, out-of-school help with mathematics (tuition), mathematics related activities with parents and family members at home or out of school. Appendix E shows the content of the questionnaire.

### 5.2.6 *Pupil behaviour questionnaire*

The Pupil Behaviour Questionnaire was completed by the teachers for every pupil in the study they taught. It gathered data on their classroom interactions, on-task behaviours, work attitudes and attendance. Appendix F shows the content of the questionnaire.

### 5.2.7 *Pupil maths learning questionnaire*

The Pupil Maths Learning Questionnaire was used to gather data from the pupils about their home support, teachers' classroom pedagogy, beliefs about mathematics, self-confidence, effort and learning preferences. Appendix G shows the content of the questionnaire.

### 5.2.8 *Pupil interview prompts*

The pupils were interviewed in small groups. The size of the group was four or five pupils. During the interview the pupils were prompted by the researchers to talk about their home support, perception of mathematics and self (confidence, effort / motivation, learning preferences) and the classroom pedagogy of their mathematics teachers. Appendix H shows the interview prompts.

### 5.2.9 *Pupil journal*

The pupils in the study were given a journal book for the school year 2010. They were encouraged to write as often as possible about their feelings, likes and dislikes about learning mathematics in their journals. Appendix I shows a page from the journal book.

### 5.2.10 *Lesson observation analytical questions*

As part of the study, lessons attended by the pupils and taught by their mathematics teachers were observed. This opportunity for the researchers was strictly voluntary on the part of the teachers in the study. The lesson observation was guided by analytical questions such as the focus of the lesson, instructional sequence, tailoring of instructions to meet the needs of different learners, characteristics of tasks used and the type of learning environment created by the teacher. Appendix J shows the list of the questions.

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