Diagnostic Assessment in Numeracy at Grade 3 – An Appraisal

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1. Introduction

The need to lay and consolidate foundations in numeracy in the early years of a child's education is vital. A significant step towards ensuring that every child is reaching the necessary developmental milestones is to monitor their acquisition of numeracy skills. An assessment framework to track such progress during early childhood had been missing for too long in the Mauritian education system. With the advent of the Nine-Year Continuous Basic Education policy (Ministry of Education, 2015), the Developmental Learner Profile (DLP) was introduced for every child in pre-primary. This profile is carried forward to Grade 1 (Year 1 of primary) so as to allow the teacher to have a better understanding of the child's attitudes and dispositions to learning in order to support and facilitate the child's transition from pre-primary to primary.

An innovative education support plan for pupils with learning difficulties, called the Early Support Programme (ESP), was set up by the Ministry of Education to provide special attention to pupils in Grades 1 and 2. This involves addressing learning difficulties at the very start with the aim of reducing learning gaps and enhancing the pupils' readiness for learning in the early years of primary schooling. Furthermore, the Primary School Readiness (PSR) and the Diagnostic Assessment (DA) were designed by the Mauritius Institute of Education (MIE) and the Mauritius Examinations Syndicate (MES), respectively. The PSR supplements the DLP as a tool to measure the extent to which pupils entering Grade 1 are sufficiently equipped with the skills and competencies to start learning successfully at primary level.

Aimed at pupils at the beginning of Grade 3, the DA is a classic example of using assessment to support learning. Pupils are assessed on key aspects of numeracy, enabling the early identification of learning difficulties. In this note, we briefly report on the philosophy and background of the DA project, the thinking behind the design of the assessment instrument, and present some findings from the 2018 assessment, all with the idea of demonstrating the potential of the DA in identifying learning difficulties. Such rich information can be very useful to the teacher to design tailor-made instructional interventions.

2. Why Diagnostic Assessment?

Concern about numeracy standards, especially the performance of the lowest achieving students, is widespread. More than a quarter of pupils in Mauritius reach the end of the primary education cycle without having acquired the basic numeracy skills. How can those who do not reach the required standards be helped? It has often been argued that "the absence of a mechanism to monitor in a systematic way children's progress in the primary cycle is a serious weakness." (Ministry of Education, 2006).

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A key aim of the DA project is therefore to provide the necessary mechanism for the identification of learning difficulties early enough in areas that have not been properly mastered. Many problem-solving behaviours are known to be related to, and in some cases are a direct consequence of, cognitive antecedents such as insufficient knowledge or unsophisticated strategy selection (Newell & Simon, 1972). It is sensible to want to draw a profile of the strengths and weaknesses of the individual pupils but also of the class as a whole, if only to increase the likelihood of those students being provided the most effective and timely instruction in a way that cuts to the origin of behaviour. With such information, teachers could alter students' misconceptions and replace faulty strategies. The data obtained should also inform headmasters of the areas where the school as a whole ought to devote more time and, given that data is also being collected from schools across Mauritius, be available to policy makers.

Data from the 2009 implementation of the DA was analysed quantitatively by Beekarry et al. (2010), where it was found that, already at this early stage of child development, gender was a significant factor impacting on performance. This analysis was extended by Hurchand et al. (2011), who examined the 2009 DA data and studied a sample of pupils' workbooks from the 2011 DA with a focus on two core areas of basic numeracy, namely addition and subtraction. They identified three types of difficulties leading to inadequate mastery of basic skills in those areas: (i) faulty conception of place value; (ii) procedural knowledge of addition and subtraction; and (iii) misconception associated with zero.

3. Designing the Assessment Instrument

At the end of Grade 2, children are expected to have acquired some basic mathematical knowledge and skills which will determine whether or not they will successfully assimilate mathematical concepts in higher grades. Fundamental skills and competencies at this stage of schooling were identified, in line with the Mathematics Teaching & Learning Syllabus (Mauritius Institute of Education, 2015), and formed the basis for the 51 items designed and grouped into 15 exercises for the assessment instrument. The items, instructions and procedures were practical, user-friendly and informative. They were chosen because they could generate information that would help in the assessment and provide diagnostic clues as to how intervention could best be provided for each pupil.

Three topics were covered, namely Number & Number Sense (items 1-39), Space & Shapes (items 40-43), and Measures (items 44-51). Some of the items, e.g. in exercises 8 (addition of whole numbers) and 10 (subtraction of whole numbers), were criterion-referenced to better discern learning difficulties (Ashlock et al., 1983; Chinn, 2016 & 2017).

The skills and competencies on which pupils were assessed in each topic are shown in Table 2.1. Details of the types of task that were set to assess each skill and competency are also specified in the table. The items which were designed were not necessarily similar to the ones pupils usually encounter in textbooks. However, instructions for each item were made as clear as possible so that pupils had no problem understanding what they were expected to do. 14 out of the 51 items (items 1, 3, 5-6, 9, 12, 21-24, 40-43) were pitched at Grade 1 level, while the rest tested pupils on Grade 2 learning outcomes.

4. Methods

The DA was administered at the start of Grade 3. The timing was a compromise between carrying out the assessment at the end of Grade 2, which would have been too late to be of diagnostic value in terms of guiding intervention, and having it done after the long summer holidays, when performance would have deteriorated in the absence of use of knowledge and practice of mathematics skills.

Grade 3 teachers in Mauritius and Rodrigues were trained by the MES to administer the DA and input the pupils' responses in a software that would generate a score sheet, which would then be used by the teacher to identify pupils having difficulties in one or more domains. To reduce the effect of language difficulty children might have at this stage, instructions for each item were given orally by the teacher in either English, French, or Mauritian Creole, whichever facilitated understanding.

The DA scores of a total of 8784 pupils (8436 from 207 schools in Mauritius and 348 from 9 schools in Rodrigues) were submitted to the MES for quantitative analysis in terms of a number of variables, such as task given, topic, skills and competencies, gender and school type (state (S), private aided² (PA) or *Zones d'Education Prioritaires*³ (ZEP)).

Topic	Skills & Competencies	Tasks	Items
Number & Number Sense	Count, read & write numbers up to 100	<ul style="list-style-type: none"> Write dictated numbers Continue a sequence of numbers or a given pattern Count a given number of objects Represent a given number using objects 	30 – 33 5 – 8 1, 2 3, 4
	Order numbers	<ul style="list-style-type: none"> Compare numbers Situate numbers Order numbers 	9 – 16 17 – 19 20
	Do simple calculations	<ul style="list-style-type: none"> Mental calculations (addition) Addition Subtraction 	21 – 24 25 – 29 34 – 39
Space & Shapes	Identify & draw geometrical shapes	<ul style="list-style-type: none"> Draw square, circle, rectangle, triangle 	40 – 43
Measures	Compare lengths	<ul style="list-style-type: none"> Distinguish the longer (shorter) objects given two or more objects 	47 – 49
	Compare masses	<ul style="list-style-type: none"> Distinguish the heavier (lighter) objects among given objects 	44 – 46
	Work with notes & coins	<ul style="list-style-type: none"> Decompose a given amount of money 	50, 51

Table 2.1: Skills and competencies assessed in the DA.

² A primary school in receipt of a grant in aid from Government funds.

³ A primary school where the pass rate in the Grade 6 examinations has been less than 40% over the last 3 years.

5. Preliminary Results and Discussions

5.1 Performance by Gender

The distribution of total scores by gender among students from state (ZEP & non-ZEP) and private aided schools is shown in Figure 5.1.

Figure 5.1: Distribution of scores by gender.

Figure 5.2: Performance of boys and girls on each item. "Nat" is the national average.

Most boys and girls performed well, with girls doing slightly, but not significantly ($p > 0.05$), better than boys - the mean scores for boys and girls are 37.92 and 39.25, respectively. This observation is in contrast with that of Beekarry et al. (2009), who found gender to be "a significant factor impacting on

performance”. Some tasks (e.g. addition and subtraction, and writing dictated numbers) proved to be negligibly more problematic for boys than for girls, as can be seen from the radar chart in Figure 5.2, where each radial direction gives the fraction of students correctly answering a particular item represented along the circumference of the chart.

5.2 Performance in ZEP and non-ZEP schools

An analysis of scores from ZEP schools not only shows a lower performance of pupils of those schools than that of pupils of non-ZEP schools (see Figure 5.3A), but a pronounced, though insignificant ($p > 0.05$), difference between the performance of boys and girls (see Figure 5.3B). In Figure 5.3B, one can see that, in ZEP schools, girls tend to outperform boys in more assessment items than seen in Figure 5.2, e.g. the tasks of comparing lengths and masses seem to be harder for boys than for girls in ZEP schools when compared to non-ZEP schools.

Figure 5.3A: ZEP vs non-ZEP performance

Figure 5.3B: ZEP Boys vs ZEP Girls performance

The disparity in performance between ZEP and non-ZEP pupils by gender is shown in Figures 5.4. The differences are statistically significant ($p < 0.05$ for both boys and girls). In fact, the contrast is greater in the case of boys. This, together with the results shown in Figure 5.3B, would mean that in ZEP schools, boys are at a higher risk of facing learning difficulties than girls, which implies that they may be in greater need of remedial intervention. Hurchand et al. (2011) found a tendency for boys to perform better than girls in ZEP schools, which we do not see in our analysis.

Looking at how pupils did in tasks grouped Grade-wise (see Figure 5.5), we see that the difference in performance between ZEP and non-ZEP students in Grade 2 tasks is on average almost twice larger than that in Grade 1 tasks; this could indicate that the gap between ZEP and non-ZEP pupils grows as pupils progress to higher grades, which would explain why ZEP students perform so drastically low compared to non-ZEP students in Grade 6 examinations. Finally, it is interesting to note that the same tendency in item facility is prevalent in both ZEP and non-ZEP schools, i.e. an item which is difficult in a non-ZEP school is equally difficult in a ZEP school.

Figure 5.4A: Boys (ZEP vs non-ZEP)

Figure 5.4B: Girls (ZEP vs non-ZEP)

A: Grade 1 level items

B: Grade 2 level items

Figure 5.5: Differences in performance in items pitched at Grade 1 (A) and Grade 2 (B) levels.

5.3 Performance by Task, Skill and Competency, and Topic

Addition and subtraction of two whole numbers remain the most challenging competencies to master for pupils starting Grade 3, with subtraction being the most problematic. Even pupils who scored well on the DA demonstrated weaknesses in these two areas. In particular, difficulties were observed in addition and subtraction problems involving zeros (item 26 for addition; items 37 & 38 for subtraction), two-digit and one-digit numbers (items 27 & 29 for addition; item 39 for subtraction),

and additions shown horizontally (items 28 & 29). In the latter case, almost half of the number of pupils did not know how to go from writing an addition horizontally to vertically.

Pupils generally did not demonstrate much difficulty in mentally adding 1-digit numbers, although adding a bigger number to a smaller one was harder than the converse for about 1 in every 5 pupils. This is probably due to the fact that children learn addition by adding smaller numbers to larger ones, and they are not taught the commutative property of addition, which is apparent from the difference in scores between $5 + 2$ (item 21) and $2 + 5$ (item 23).

Almost a third of the pupils had difficulty telling which of "fourteen" and "forty" is greater (item 16). This shows that pupils struggled to distinguish between names of number ending with "teen" and "ty". For item 18, more than a quarter of the pupils could not choose the number which is a multiple of 10 that lies between 45 and 65, both of which are multiples of 5.

Figure 5.6 shows the performance of pupils on items grouped by tasks (red lines), skills and competencies (green lines), and topics (blue lines), according to Table 2.1. The most and least problematic areas are listed in Table 5.1.

Figure 5.6: Performance by Tasks, Skills and Competencies, and Topics (see Table 2.1)

	Most problematic	Least problematic
Task	Subtraction	Represent a given number using objects
Skills & Competencies	Work with notes & coins	Count, read & write numbers up to 100
Topic	Measures	Space & shapes

Table 5.1: Most and least problematic areas identified.

6. Conclusions and Future Directions

Analysis of the 2018 DA data revealed that a significant number of pupils, especially in ZEP schools, continue to demonstrate difficulties in basic numeracy after two years of primary schooling. The results of this study show the limited mastery of basic skills in addition and subtraction, both of which are instrumental in constructing mathematical knowledge. The acquisition of a number of skills and competencies in numeracy by pupils at the end of Grade 2 continues to be poor across the curriculum.

Overall, we see no significant difference in performance at this age between boys and girls, who show a very strong tendency in facing the same learning difficulties, and that at a national level. However, the situation is different when we compare the performance of pupils in non-ZEP schools with that of boys in ZEP schools, where the former fare significantly better ($p < 0.05$) than the latter in the DA. This means that pupils in ZEP schools are at a higher risk of facing learning difficulties than those in non-ZEP schools, which means that more support, in terms of special intervention, should be given to ZEP schools. Important life skills such as distinguishing between lengths and masses of objects, and working with notes and coins, have not been developed by most pupils at this age.

The fact that the pupils who are “at risk” in their learning can be identified in each school provides an opportunity for follow-up action to be undertaken to confirm the findings and to gauge the extent of their difficulties. These pupils would range from those who have not fully acquired basic competencies and who need some support to build their confidence, to those who have acute problems requiring personalised attention, and in some cases specialised attention. For the latter category of pupils, the need to have targeted intervention programmes in numeracy is certainly being felt.

The establishment of such remedial arrangements, together with an alignment of the PSR with the DA so as to better determine whether a lack of homogeneity in teaching at pre-primary could be contributing to children not developing basic skills in numeracy in early childhood, would form an important component of the remedial strategy programme of the Ministry of Education. This would pave the way towards the successful primary schooling of all pupils.

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