The Challenge of Meeting the Instructional Needs of Grade 1 and Grade 2 Children Who Are at Risk in Mathematics

Ann Gervasoni
Australian Catholic University~Ballarat
<a.gervasoni@aquinas.acu.edu.au>

Following assessment by their teachers, about 40% of Grade 1 and Grade 2 participants in the Early Numeracy Research Project were identified as vulnerable in aspects of number learning. This paper explores the domains and combinations of domains in which these children were vulnerable. The findings highlight the diversity of the instructional needs of this group and the challenge teachers face in meeting their diverse needs.

The Australian Commonwealth Government developed a National Literacy and Numeracy Plan (Department of Education Training and Youth Affairs, 2000) to improve literacy and numeracy outcomes for Australian students. The National Plan recognises that "there is a need to provide effective assistance to students who need extra support, as part of ensuring that all students gain a level of numeracy essential for successful participation in schooling, in work, and in everyday life (p. 6)." As a result, the National Plan calls for the assessment of all children by their teachers early in schooling, and the "provision of intervention for those students identified as being at risk of not making sufficient progress" (p. 7). Prevention and intervention in early childhood is viewed widely in the community as important for increasing the opportunities of children at risk of poor learning outcomes, and for ensuring the educational success and general wellbeing of young people (Doig, McCrae, & Rowe, 2003; McCain & Mustard, 1999; Ochiltree & Moore, 2001; Shonkoff & Phillips, 2000). However, prevention and effective intervention requires knowledge about the instructional needs of vulnerable students.

This paper explores the instructional needs of Grade 1 and Grade 2 children who, following assessment by their teachers, were identified as vulnerable in aspects of learning school mathematics. The particular focus is number learning in the domains of Counting, Place Value, Addition and Subtraction, and Multiplication and Division. This research investigates how many Grade 1 and Grade 2 participants in the Early Numeracy Research Project (ENRP, Clarke, Cheeseman, Gervasoni, Gronn, Horne, McDonough, Montgomery, Roche, Sullivan, Clarke, & Rowley, 2002) were vulnerable in each domain, and the combinations of domains for which these children were vulnerable. Of particular interest is whether there are any patterns in the domains or combinations of domains for which children were vulnerable. The findings have potential for informing both classroom teachers and mathematics intervention teachers about the instructional needs of the group of children who are vulnerable in learning mathematics.

Vulnerability and Responding to Children's Individual Learning Needs

The research reported on in this paper was based on the assumption that it is important for school communities to identify children who, as emerging school mathematicians and after one year at school, have not thrived in the school environment, and to provide these children with the type of learning opportunities and experiences that will enable them to thrive and extend their mathematical understanding. Further, the perspective that underpinned this research was that any children who have not thrived, have not received the type of experiences and opportunities necessary for them to construct the mathematical

understandings needed to successfully engage with the school mathematics curriculum, or to make sense of the standard mathematics curriculum. As a result, these children would be *vulnerable* and possibly at risk of poor learning outcomes. The term *vulnerable* is widely used in population studies (Hart, Brinkman, & Blackmore, 2003), and refers to children whose environments include risk factors that may lead to poor developmental outcomes. The challenge remains for teachers and school communities to create learning environments and design mathematics instruction that enables vulnerable children's mathematics learning to flourish.

A common theme expressed by researchers in the field of mathematics learning difficulties is the need for instruction and mathematics learning experiences to closely match children's individual learning needs (e.g., Ginsburg, 1997; Greaves, 2000; Wright, Martland, & Stafford, 2000). Rivera (1997) believes that instruction is a critical variable in effective programming for children with mathematics learning difficulties, and that instruction must be tailored to address individual needs, modified accordingly, and evaluated to ensure that learning is occurring.

Ginsburg (1997) articulated a process for responding to children's learning needs that used Vygotsky's zone of proximal development (Vygotsky, 1978). Ginsburg's process requires that the teacher first analyses children's current mathematical understandings and identifies their learning potential within the zone of proximal development. For this purpose, the notion of a framework of growth points or stages of development is important for helping teachers to identify children's zones of proximal development in mathematics, and thus identify or create appropriate learning opportunities. This approach is aligned also with the instructional principles advocated by Wright et al. (2000) for the *Mathematics Recovery* program. They believe that instruction for low-achieving children should be closely aligned to children's initial and ongoing assessment, and should be at the 'cutting edge' of each child's knowledge (Wright et al, 2000). The ENRP research team also advocated this approach. Indeed, a feature of the ENRP was the use of a mathematics assessment interview and associated framework of growth points that enabled teachers to identify children's current mathematical knowledge, and locate children's zones of proximal development. Further, the assessment process enabled those children who were vulnerable in aspects of learning mathematics to be identified. The question remains as to whether this group of students have similar or diverse instructional needs.

Identification of Vulnerability in Mathematics for Grade 1 and 2 Children

The participants in this research were 1497 Grade 1 children and 1538 Grade 2 children from 34 ENRP trial schools. These schools included Government, Catholic and Independent schools from across Victoria that were widely representative of the Victorian population. This was important for enhancing the external validity of the results (Campbell & Stanley, 1963). In order to determine whether their instructional needs were similar or diverse, this research first required a method for identifying children who were vulnerable in aspects of learning mathematics. This meant that the domains for which these children were vulnerable could then be analysed.

In order to identify children who are vulnerable, often a line is drawn across a distribution of test scores, and children 'below' the line are deemed at risk and are recommended for a specialised program (Ginsburg, 1997; Woodward & Baxter, 1997). The decision about where to 'draw the line' is arbitrary, but in this research was made on the basis of *on the way* growth points (Gervasoni, 2000). The *on the way* growth points relate to a framework of growth points in nine domains that were research based and drew

on what was known about the course of children's mathematical knowledge formation (Clarke, 2001). Importantly, the *on the way* growth points indicate children who have constructed the mathematical knowledge that underpins the initial mathematics curriculum in a particular domain and grade level, and who are likely to continue to learn successfully. Not yet reaching the *on the way* growth point in a particular domain is an indicator that children may be vulnerable in that domain and may benefit from opportunities to help them reach the *on the way* growth point as quickly as possible. Otherwise, they may not benefit from all classroom mathematics learning experiences because they do not have the conceptual knowledge that underpins these experiences.

The development of appropriate *on the way* growth points for Grade 1 and 2 children was guided by three data sources: the ENRP growth point distributions for Grade 1 and Grade 2 children in March 2000; the Victorian Curriculum and Standards Framework II (Board of Studies, 2000) for Grade 1 and Grade 2; and the opinions of ENRP Grade 1 and Grade 2 classroom teachers (Gervasoni, in press). The analyses and synthesis of these data resulted in the following *on the way* growth points being established for Grade 1 children (Gervasoni, in press) in Counting, Place Value, Addition and Subtraction, and Multiplication and Division respectively:

- counting collections of at least 20 items (Growth Point 2);
- reading, writing, ordering and interpreting one digit numbers (Growth Point 1);
- counting-all in addition and subtraction situations (Growth Point 1); and
- counting group items as ones in multiplication and division tasks (Growth Point 1).

The *on the way* growth points established for Grade 2 children were:

- counting forwards and backwards beyond 109 from any number (Growth Point 3);
- reading, writing, ordering and interpreting two digit numbers (Growth Point 2);
- counting-on in addition and subtraction situations (Growth Point 2); and
- using group structures to solve multiplication and division tasks (Growth Point 2).

In order to determine the growth points reached by each child, all ENRP participants mathematics knowledge was assessed at the beginning and end of the year (March and November) using the ENRP assessment interview (Clarke, 2001), and their growth points in Counting, Place Value, Addition and Subtraction, and Multiplication and Division were determined (Rowley, Gervasoni, Clarke, Horne, & McDonough, 2001) and entered into an SPSS database (SPSS Inc., 2002). The interviews used a clinical interview approach (Ginsburg, 1997), took between 30-40 minutes for each child and were conducted by the classroom teacher. Procedures were developed and implemented to maximise consistency in interview administration across all schools (Rowley et al., 2001) in order to enhance the validity and reliability of the assessment data collected, and to ensure that the data were as consistent and as free from bias as possible. Procedures were also implemented to enhance the consistency with which the growth points were assigned for each child (Rowley et al., 2001). This meant that a large database of reliable and valid growth point data (Rowley & Horne, 2000) that was representative of the Victorian population was available for analysis.

For the purposes of this research, those who were vulnerable in each domain were identified using a process developed by Gervasoni (in press). This involved examining children's growth point profiles to identify those who had not reached the on the way growth points in each domain (Gervasoni, 2000). In order to identify whether there were any patterns in the domains or combinations of domains for which children were vulnerable, the children's growth point data was examined to determine the number of Grade 1 children and Grade 2 children who were vulnerable in each domain, and the

number of children who were vulnerable in each combination of domains. It was anticipated that any patterns identified would be useful for teachers to know about so that they could respond more fully to children's individual learning needs.

The Domains and Combinations of Domains for Which Children Were Vulnerable

The analysis of ENRP participants' growth point data found that the number of Grade 1 children in 2000 who were vulnerable in at least one number domain was 576 (n=1497). This represented about 38% of the Grade 1 children. The number of Grade 2 children in 2000 who were vulnerable in at least one number domain was 659 (n=1538). This represented about 43 percent of the Grade 2 children. The number of children who were vulnerable in each number domain is shown in Table 1.

Table 1
Number of Children in 2000 Who Were Vulnerable in Each Number Domain

Domain	Grade 1 (n=1497)	Grade 2 (n=1538)
Counting	163 (11%)	371 (24%)
Place Value	149 (10%)	417 (27%)
Addition and Subtraction	176 (12%)	294 (19%)
Multiplication and Division	423 (28%)	280 (18%)

These data indicate that more of the Grade 2 children were vulnerable in Counting, Place Value, and Addition and Subtraction than was the case for Grade 1 children, but that more Grade 1 children were vulnerable in Multiplication and Division. Hypothetically, these data suggest that in a typically sized Grade 1 class of 24 students, about ten children (38%) will not have reached all four *on the way* growth points in the number domains. About three of these ten children will not have reached the *on the way* growth point in Counting, two or three children will not have reached the *on the way* growth point for Place Value, three children will not have reached the *on the way* growth point for Addition and Subtraction, and seven children will not have reached the *on the way* growth point for Multiplication and Division. Few Grade 1 children would be at risk in more than one domain. This finding highlights the complexity of teaching mathematics and of identifying and meeting children's individual instructional needs.

For Grade 2 children, the situation is a little different. Overall, about the same percentage of Grade 2s as Grade 1s did not reach all of the *on the way* growth points (43%). This again equates to about ten children in a typical Grade 2 classroom. However, more of these Grade 2 children can be expected to be at risk in multiple domains than was the case for their Grade 1 counterparts. In a typical Grade 2 class of 24, the data suggest that about six of these hypothetical ten children will not have reached the *on the way* growth point in Counting, six children will not have reached the *on the way* growth point for Place Value, four or five children will not have reached the *on the way* growth point for Addition and Subtraction, and four children will not have reached the *on the way* growth point for Multiplication and Division. Therefore, Grade 2 children who have not reached all the *on the way* growth points are more likely to be vulnerable in multiple domains than Grade 1 children. Responding to each of these children's instructional needs is a challenge for teachers.

Figure 1 provides a diagrammatic representation of the intersecting domains for which the Grade 1 children were vulnerable. The number of ENRP children who were vulnerable in the intersecting domains is also shown (*n*=1497). The intersections between Counting and Addition and Subtraction, and Place Value and Multiplication and Division, are shown with additional circles. The number of Grade 1 children who were vulnerable in at least one domain was 576.

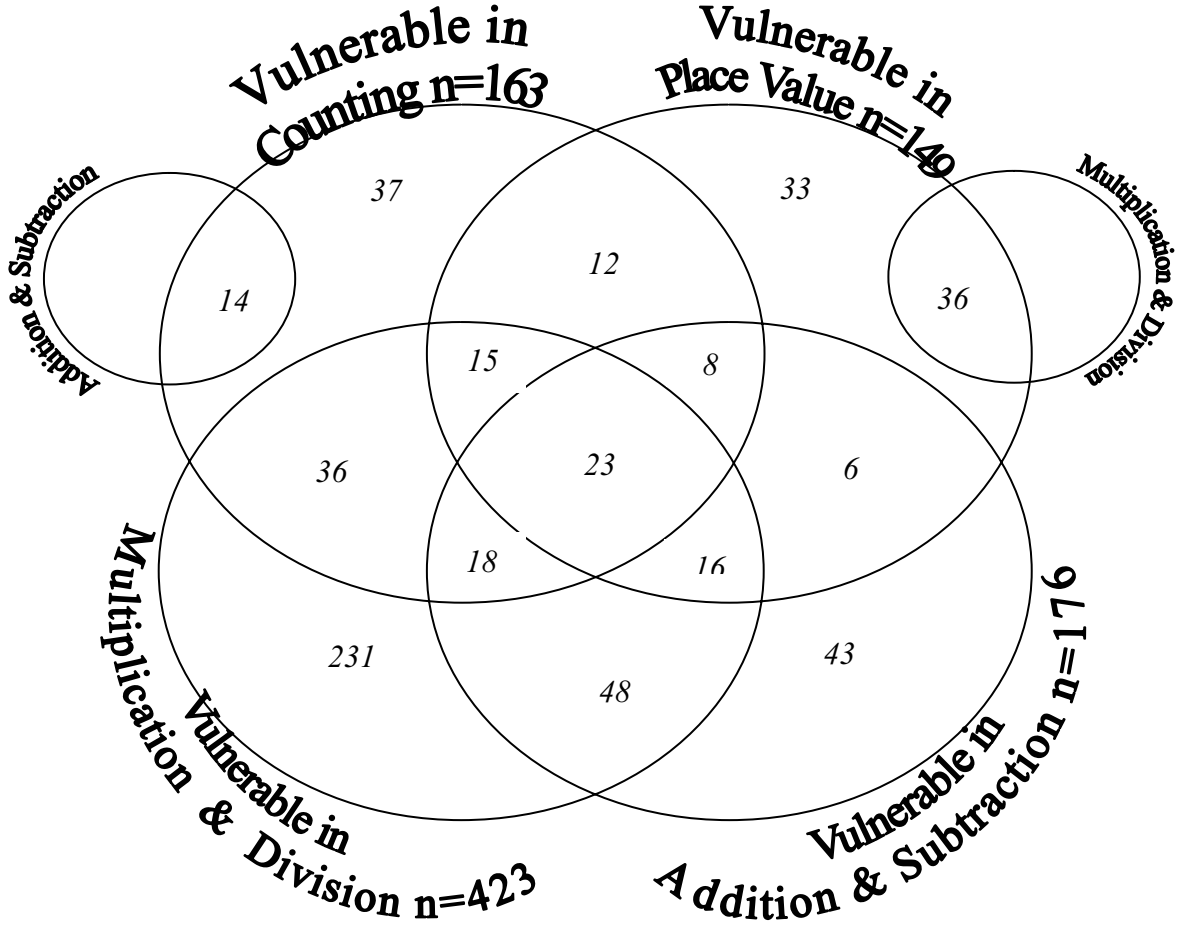

Figure 1. Diagrammatic representation of the intersecting domains for which Grade 1 children were vulnerable (n=576).

A similar diagram indicating the intersecting domains for which Grade 2 children were vulnerable is shown in Figure 2 (n=1538). The number of Grade 2 children who were vulnerable in at least one domain was 659.

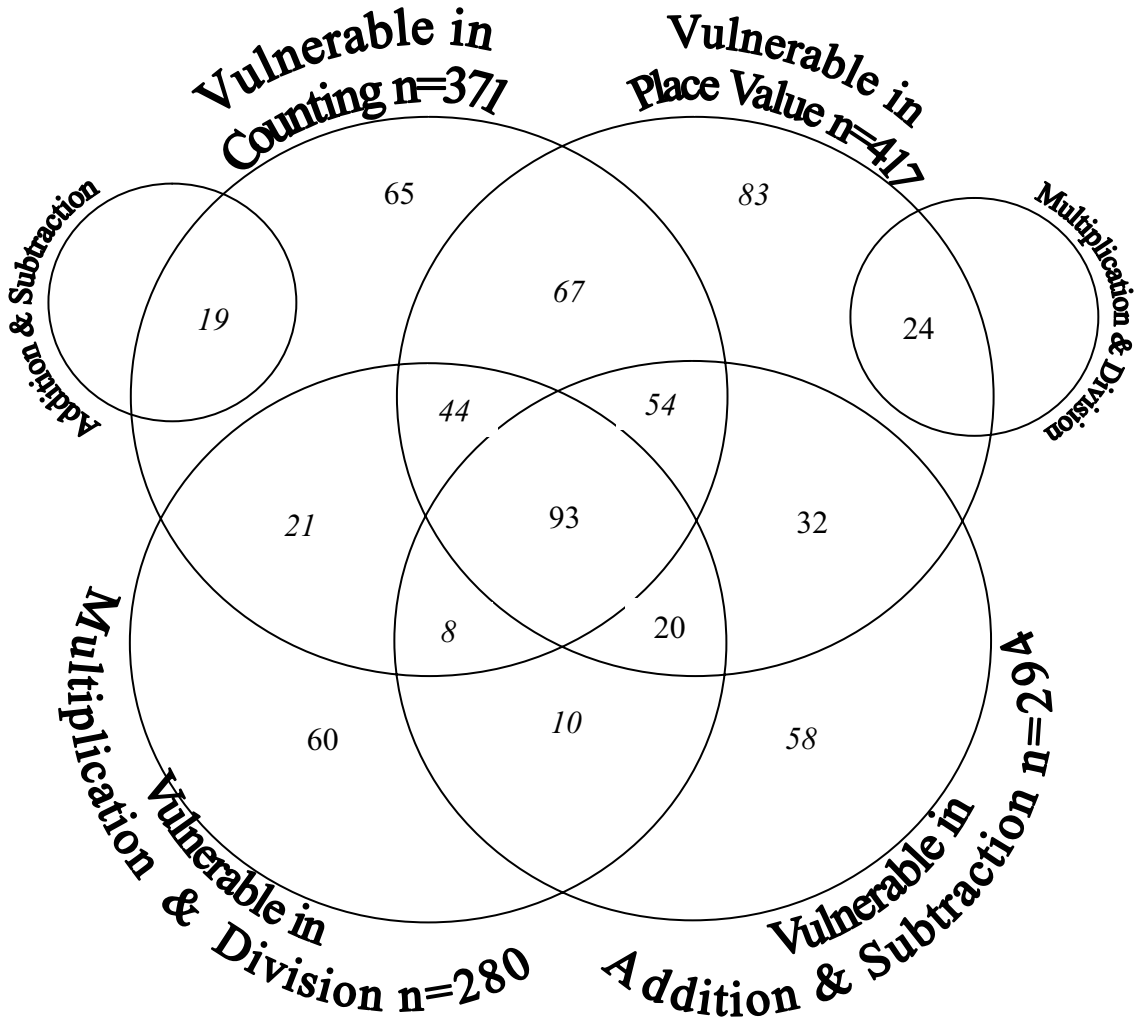

Figure 2. Diagrammatic representation of the intersecting domains for which Grade 2 children were vulnerable (*n*=659).

These diagrams highlight several issues. First, many of the Grade 1 children were vulnerable in Multiplication and Division only, and few Grade 1s were vulnerable in three or four domains. In contrast, about one third of the Grade 2s were vulnerable in three or four domains, and the least number of children were vulnerable in Multiplication and Division. Most Grade 1 and 2 children were vulnerable in either one or two domains.

In both Figure 1 and Figure 2, the diversity of domains and combinations of domains in which children were vulnerable is striking. There was a spread of vulnerability across all domains, and there were not any combinations of domains that were common for the children who were vulnerable. Thus, there was no single 'formula' for describing children who were vulnerable in learning school mathematics, or for describing the instructional needs of this diverse group of students. Also, the results suggest that it is not possible to assume that because a child was vulnerable in one number domain, then they will be vulnerable in another number domain. This finding may surprise some teachers.

Discussion and Implications

The findings presented in the previous section highlight the diversity of mathematical understandings amongst the group of Grade 1 and Grade 2 children identified as vulnerable in aspects of learning school mathematics. This group is far from being a homogeneous one. Indeed, there were no patterns in the domains in which children were vulnerable, or in any combinations of domains for which children were vulnerable. Vulnerability was widely distributed across all four domains and combinations of domains in both grade levels. However, one feature of the findings for Grade 1 children is worth noting. Twice as many Grade 1 children were vulnerable in Multiplication and Division than for any other domain, but this level of vulnerability was not maintained for Grade 2 children. It is possible that this finding is an artefact of the mathematics curriculum in Victoria. The *Mathematics Curriculum and Standards Framework II* (Board of Studies, 2000) does not recommend Multiplication and Division experiences for children in the first year of school, and it is therefore likely that some teachers may not provide such learning opportunities for their students. The fact that so many Grade 1 children have reached the *on the way* growth point for Multiplication and Division indicates that children may indeed benefit from opportunities to enhance their construction of knowledge in the Multiplication and Division domain throughout the first year of school. If this were to occur, then perhaps fewer Grade 1 children would be identified as vulnerable in the Multiplication and Division domain.

The findings have several other implications for the instructional needs of children. Most importantly, the results indicate that children who are vulnerable in aspects of learning school mathematics have diverse learning needs, and this calls for particular customised instructional responses from teachers. It is likely that teachers will need to make individual decisions about the instructional approach for each child, and that there is no 'formula' that will meet all children's instructional needs. Further, the diversity of children's mathematical knowledge in the four domains suggests that knowledge in any one domain is not necessarily prerequisite for knowledge construction in another domain. For example, some teachers may assume that children need to be *on the way* in Counting before they are ready for learning opportunities in Addition and Subtraction. On the contrary, the findings presented in Figures 1 and 2 indicate that some children who are not *on the way* in Counting are already *on the way* in Addition and Subtraction, and this pattern is maintained for the other domains also. This finding has implications for the way in which the school mathematics curriculum is introduced to children. It seems likely that children will benefit from learning opportunities in all four number domains, provided in tandem with one another, and that learning opportunities in one domain should not be delayed until a level of mathematical knowledge is constructed in another domain.

Conclusion

The findings presented in this paper highlight the diversity of domains and combinations of domains in which Grade 1 and Grade 2 children were vulnerable, and the challenge that teachers face when tailoring instruction to meet children's individual learning needs. One advantage of mathematics intervention programs is that teachers have more opportunity to customise instruction for each child. This is important for increasing the opportunities of children at risk of poor learning outcomes in mathematics.

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