Numeracy at Home: Involving Parents in Mathematics Education

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Parental involvement in the form of 'at-home' interest and support has a major influence on pupils' educational outcomes and attitudes. Many parents, however, feel uninformed about current educational practices and how they can be more involved with their child's learning. A number of initiatives have been implemented internationally to encourage home-school links, but the documentation of these initiatives, particularly in the area of mathematics education is limited. This article provides some examples of mathematics education projects, initiatives and interventions as documented in the literature, as a context for discussing in detail two initiatives undertaken with the parents of two Australian schools. The projects point to parents as being important advocates in promoting mathematical reform and contemporary practice, with the article in general adding to the limited documentation available on the nature of such projects that cater for the needs of parents.

Research on interventions to promote parental involvement in their children's education documents a range of approaches, including parent training programs and initiatives to enhance home school links (Desforges & Abouchaar, 2003). While there is widespread agreement in the literature that students' learning is maximised when strong educational partnerships between home and school exist (e.g., Groves, Mousley & Forgasz, 2006; Stephens & Steinle, 2005; Anthony & Walshaw, 2007), the nature of these partnerships, particularly in the area of mathematics education, is not extensively documented. This article provides some examples of mathematics education projects, initiatives and interventions as documented in the literature as a context for discussing in detail two initiatives undertaken with the parents of students from two Australian schools.

The initiatives identified in the literature and described in this paper occurred in the context of a wider mathematical reform movement. The momentum for reform in mathematics education began in the early 1980s (Van de Walle, 2004), with a change of focus from mathematics content to how students can best learn mathematics. Advocates of reform urged a move away from traditional teaching approaches which emphasised telling and practice of procedures (Olson & Barrett, 2004), to approaches which supported a constructivist view of learning (Van de Walle, 2004), in helping students construct meaningful conceptions of mathematical topics (Fraivillig, Murphy & Fuson, 1999). The reform movement was based on the recommendations of the NCTM Standards document (1989), and despite reform documents and organisations such as the NCTM advocating the need to work with parents (NCTM, 2000), Peressini (1998) maintained that parents have traditionally been seen as "impediments to the reform of mathematics education" (p. 14). He argues however, that parents have their own expertise and unique knowledge about their children and thus can contribute to their children's mathematical development. Furthermore, those parents who had negative experiences in their own mathematical education may view reform recommendations in mathematics education as welcome changes that could result in more engaging and meaningful mathematical experiences for their children (Peressini, 1998).

An earlier paper (Muir, 2009) described the use of an intervention program designed to engage parents in participating in mathematical activities with their children at home. The findings indicated that despite holding many traditional views of mathematics, the parents were supportive of contemporary mathematical practices and were able to contribute to their child's mathematical education. This paper provides additional information on how the intervention program was designed and organised, and how it evolved into another project

which focused more on developing parents' own mathematical knowledge and understandings, along with engaging parents in continuous mathematical involvement as their children progressed through their schooling. As such, it is particularly applicable to practitioners who may be looking to initiate similar projects into their own educational context.

Theoretical Background

Parents and mathematical reform

As previously mentioned, the momentum for reform in mathematics education began in the early 1980s (Van de Walle, 2004), in response to a "back to basics" call to address community concerns about the state of mathematics education. Although "basic" means different things to different people, it typically consists primarily of arithmetic or computation based on drill and practice (Cavenagh, 2006) and is the mathematics that parents and legislators recognise as the subject they were taught in schools. Reform-oriented approaches, on the other hand, are based on the recommendations made by the NCTM (1989) and involve a range of processes, such as problem solving, reasoning and proof, communication and reflection (Bobis & Anderson, 2006). Reform advocates want students to value mathematics and be confident in their ability to do mathematics (Van de Walle, 1999). Consistent with the reform approach, is an increased emphasis on the need for students to develop a conceptual understanding of important mathematical ideas and an ability to connect these ideas, in order to build up a network or foundation on which to base future learning. According to Van de Walle (1999), reform and basics are not opposite ends of the same continuum; rather, the basics tend to be about content (specifically content that was common when today's adults were in school), whereas reform is much more about how children learn.

The implications of establishing working partnerships between home and schools in the context of the reform movement mean that careful consideration needs to be given to the ways in which reform practices are communicated to parents and the extent to which teachers can expect parents to follow, implement and support reform practices. Edward & Warin (1999) found, for example, that there were considerable discrepancies between approaches recommended to 'volunteers' and their actual practice. In addition, they found that teachers were often unaware of the demanding nature of the tasks they were expecting parents to do and tended to under-estimate the professional expertise of teachers.

It is also important to acknowledge the tension that exists between how mathematics is taught today compared with how it was learned by parents (e.g., Civil, 2006; Marshall & Swan, 2010; Peressini, 1998). Many parents tend to value their own forms of doing mathematics (Quintos, Bratton & Civil, 2005) over 'school mathematics', while many children value schools' form of knowledge over the parents' knowledge, hence demonstrating the potential tensions that may arise when engaging in mathematical tasks and assignments at home. Adding to the potential for creating tensions, parents in Civil's (2006) project expressed concerns that they were not familiar with the homework tasks set, and therefore unsure about the best ways in which to help their children. Similarly Muir (2009) found that only 36% of parents surveyed indicated that they had a good understanding of how their child was taught mathematics, and McNamara et al. (2000) also found that parents often expressed the desire for more help and direction from school with regard to how to help their child. Pritchard (2004) also found that many parents felt uninformed about the mathematics curriculum and the teaching methods used in their child's school, thereby limiting the ways that they could be involved in their child's mathematics education (Peressini, 1998). Without being informed about the rationale or purpose behind contemporary practices, there is a danger that parents may view practices, such as the use of games and manipulative materials,

as time wasting and unproductive (Marshall & Swan, 2010; Onslow, 1992). These considerations were taken into account when designed the interventions discussed further on in this paper.

Parental attitudes and beliefs

Pritchard (2004) synthesised a number of studies that concluded there were links between parents' attitudes, perceptions and beliefs about mathematics and children's attitudes and performance in mathematics. Hall and Davis (1999; as cited in Pritchard, 2004), for example, claimed that parental attitudes influenced students' performance in mathematics and that parents communicated their beliefs and attitudes about mathematics through their individual practices. McNamara et al. (2000) found that parents' own lack of skill, knowledge and confidence was a recurring theme, with maths in particular being a source of much family angst. Other research findings indicate that many adults, in relation to mathematical tasks, admit to feelings of anxiety, helplessness, fear and dislike (Haylock, 2007). Issues of lack of confidence, of feeling inadequate at mathematics, and of feeling alienated were common among Civil's (2001) participants in a 'Maths for Parents' course. This is of concern as presumably many of these adults are parents who will potentially pass these feelings on to their children. Although many parents do consider mathematics to be important, they also tend to think it is dull and boring and based on the memorisation of rules and procedures (Onslow, 1992). Students' attitudes have been found to be strongly influenced by the attitudes of their parents (e.g., Onslow, 1992) so it would seem beneficial, therefore, to invest time and resources into addressing parents' perceptions of mathematics and mathematics education. The second project reported on further in this paper evolved when it was recognized that parents may be more willing to become involved in their child's mathematical education if they more fully understood the mathematics, along with being more informed about current mathematical pedagogical practices.

Parental involvement

Studies have shown that students performed better academically and had more positive school attitudes if they had parents who were aware, knowledgeable and involved (Epstein, 1992, as cited in Anthony & Walshaw, 2007). Rich learning environments that incorporate meaningful mathematical experiences are associated with higher achievement and genuine home/school collaboration has also been found to lift children's achievement significantly (Biddulph, Biddulph & Biddulph, 2003). Results from a study conducted by Cai (2003) indicated that parental involvement is a statistically significant predictor of their children's mathematical achievement and also promoted positive behaviours and emotional development. Cai (2003) identified five parental roles in middle school students learning of mathematics: motivator, monitor, resource provider, mathematics content advisor, and mathematics learning counsellor. He concluded that the roles of motivator and monitor seemed to be the most important influences on children's problem solving performance. Cai's study also looked at the differences in parental support provided by Chinese and US parents; interestingly, only about 36% of Chinese parents indicated that they "knew enough about mathematics to help my child" (Cai, 2003, p. 97), supporting other findings that parental involvement tends to diminish with grade level, which could be attributed to the increasing complex nature of mathematics as students move through grades, with parents lacking the content knowledge or teaching skills needed to help their children (Sheldon & Epstein, 2005).

In the United States, Civil (1998) has attempted to address lack of parental involvement through recognising that parents are valuable resources who can be utilised for mathematical

instruction. Her research has focused on linking home and school, particularly in the context of working class and immigrant families. A series of workshops, conducted in a similar way to professional learning provided to teachers, combined with home visits and interviews, provided valuable information about parents' everyday practices and experiences. Furthermore, the workshops contained reform-based activities which encouraged the use of non-traditional approaches with a focus on investigation – a contrast to what many of them experienced in their own schooling. Math and Parent Partnerships in the Southwest (MAPPS) aimed to assist parents to help their children with their school mathematics work and to develop leadership capital among parents (Quintos, et al., 2005), while Project BRIDGE (Linking home and school: A bridge to the many faces of mathematics) focused on parents learning mathematics with understanding (Civil, 2001). Both projects have realised the potential that parents have in terms of contributing positively to their children's mathematical education.

Two major UK projects that are well documented in the literature are the IMPACT project (Merttens & Vass, 1993) and the Ocean Mathematics Project (Bastiani, 2004; Bernie & Lall, 2008). The IMPACT project began in London in 1985 and involved children and parents sharing regular maths activities together, with the results returned to the classrooms to inform the following week's work (Merttens & Vass, 1993). According to one of the teachers involved in the project, IMPACT helped make parents more confident in being involved in school activities and that they valued being an integral part of their child's education (Tye, 1993). Participating teachers viewed it as a way of showing parents the kind of maths that takes place in schools and reported that parents were now better informed about the need for practical experience, the power of games to motivate practice and the importance of paying attention to children's attitudes (Bristow, 1993). One of the features of the program was the inclusion of a built-in facility for parents to respond to the activities, making them "no longer passive and compliant to the diet of learning that the school is feeding their children" (Morgan & Tremere, 1993, p. 66). The Ocean Mathematics Project began in 2001 and sought to "address underachievement in mathematics by changing the attitudes and practices of schools, parents and children, specifically through involving their parents in their child's mathematics learning process" (Bernie & Lall, 2008, p. 4). The project involves delivering workshops to parents and giving pupils specially designed homework, usually focused on games that children and parents or carers can play together. In contrast with IMPACT, the homework is given every two weeks, or five activities per term. Reports of the project have indicated an increase in pupil achievement (Bastiani, 2004), improvements in parents' own mathematical understanding, transfer of methodology from teachers to parents and increased parental involvement in school life and in their child's education generally (Bernie & Lall, 2008).

In Australia and New Zealand there are no documented cases of similar wide-scale projects; instead there are general resources made available to encourage parental participation in mathematics education (e.g., Morony, 2004; Ministry of Education, 2008), and isolated examples of interventions and initiatives, such as teacher-designed interactive homework (Sheldon & Epstein, 2005) and "take-home packs" of mathematical activities (Goos & Jolly, 2004: Muir, 2009). Other research (e.g., Marshall& Swan, 2010; Muir, 2011) has documented the limited examples of conducting workshops with parents, finding them to be successful in increasing parents' confidence about assisting their child with mathematics.

The Projects

The projects described in this paper, 'Engaging families in numeracy' and Maths Club for Parents arose from a small Community Engagement Grant which was aimed at involving

parents in their child's mathematical education. 'Engaging families in numeracy' was initiated in 2008 at Pleasant Hills District High School,[1] and later extended to Mountain Ville District High School in 2010; the Maths Club for Parents was introduced in Mountain Ville District High School in 2010. Both projects are currently ongoing.

Engaging families in numeracy

Before establishing this project in each school, preliminary data about parents' attitudes and beliefs towards mathematics, how mathematics is taught in schools and how parents engaged in mathematical experiences with their children were collected through questionnaires. The design of the questionnaire was influenced by similar instruments used in other studies seeking information about participants' beliefs and attitudes (e.g., Pritchard, 2004; White, Way, Perry & Southwell, 2005). The questionnaire contained 22 rating scale items and five open-ended questions and was sent home with each child in the classes. Similar items were used by Marshall and Swan (2010) in a survey used to gain information about parents' perceptions of, and confidence with, using mathematics and helping their children with mathematics. The results of the questionnaires are documented elsewhere (Muir, 2009; Muir (in press)).

The intervention program involved each child taking home a different numeracy activity each week. The activities were designed and/or selected by the author and the classroom teachers, were interactive and supported the mathematical experiences undertaken in the classroom. They were predominantly game based, required few materials and could be undertaken more than once. Approximately thirty numeracy bags were created for each class, with some activities repeated. Each numeracy bag contained activity instructions, necessary materials and guidelines for parents. Most activities were also accompanied by a short explicit rationale that explained the mathematical purpose behind the activity. Figure 1 shows an example of one of the activities and how it was presented. Every Monday each child would receive their numeracy bag, take it home and preferably engage in the activity 2-3 times over the week with their parents and/or other family members. The bag would then be returned to school on Friday, with a new activity taken home on the following Monday. Similar to the strategy used in the IMPACT project, each activity bag contained a feedback sheet which required parents to provide information about their child's level of engagement with the activity and any mathematical understandings that were revealed (see Appendix A). This written feedback was collated and used to inform the evaluation of the project and is documented elsewhere (see Muir, 2009).

At Pleasant Hills District High School the numeracy at home bags were initially introduced in a Grade 1/2 class (6-7 year old students) in 2008. The project was then extended to a prep/1 (5-6 year old students) and 3/4 class (7-8 year old students) in 2009, and a Grade 4/5 class (9-10 year old students) in 2011. The project was introduced to a prep/1 class at Mountain Ville District High School in 2010 and plans are underway to extend the practice throughout the school. As each class adopted the practice, the author met with the classroom teacher and two to three days were spent selecting the activities, and creating and organising the resources. Parent information sessions were held for the parents of the students in each class prior to the numeracy bags being sent home. The sessions provided parents with an overview of the aims of the program, some current mathematical teaching practices and the opportunity to engage in some of the activities.

As reported in Muir (2009), the return rate for the weekly feedback sheets was high, with comments revealing that parents were able to identify and describe some of the mathematical

[1] Pseudonyms used for schools and all participants

behaviours they observed. For example, one activity required children to place different combinations of counters in a ten-frame, and the following feedback was received from the parent:

> She placed the counters in a 'logical' way and could easily tell me how many counters she needed to make 10

Other mathematical comments received also indicated that parents were able to provide important information about their child's mathematical understandings, enabling the classroom teacher to capitalise and build on this in class.

Questionnaires and interviews were used to gather feedback from the participants as a way of evaluating the project. Participants indicated that they viewed the project positively and would like to see it continued. Participants also reported that it gave them an increased understanding of how mathematics was taught in their child's classroom and more insight into their child's own mathematical understandings. Many comments also indicated support for contemporary mathematical practices, with the following being illustrative of the feedback received:

> Even though it looked like you were just playing a game you could see the benefit of the numeracy and the maths skills that were in it

Feedback from the teachers was also positive, particularly in terms of providing a link between school and home:

> Sometimes they'll [parents] come in and say that was a bit hard; but generally really positive comments – saying how we did that or talk about the activity; it's been really good for parents to see the purpose behind what we're doing; it has certainly been worth doing and I'd like to keep it going – maybe in more of a self-serve way – have a bank of about 40 in room and still monitor it to make sure everything is returned – like they do with their home readers.

In terms of monitoring and maintaining the project, it is recommended that the activities selected require minimal preparation and few additional materials. From time to time it was necessary to replace the instructions or missing resources, such as dice and cards, but on the whole this was not an issue. Each bag contained a list of contents on the outside, which assisted with monitoring this aspect. A strategy utilised to maintain motivation was to regularly introduce 'new' activities, sometimes with a novelty aspect. For example, some large 20-sided foam dice and 'giant' calculators (see Figure 2) were purchased which proved very popular with all classes.

The Maths Club

The Maths Club was introduced to the second school, Mountain Ville District High School in 2010. The prep/1 class were already using the numeracy at home bags, with positive feedback being received from parents. Senior staff at the school, however, felt that parents of older students were not being catered for and informal conversations with parents in the playground and at Parent-Teacher nights indicated that mathematics was an area in which they felt less confident with helping their children. An open invitation was then given to all parents via the school newsletter to join the Maths Club.

The first session was held on an afternoon and was attended by 18 parents who had children in classes ranging from kinder to high school. The session was designed to be interactive in nature, with the content being presented in a light-hearted way, through an idea sourced by Cheeseman (2007) involving the 'busting' of mathematical myths. Prior to commencing the session, each participant was asked to complete an 'Anticipation Guide' (Tierney & Readance, 2005) in which they indicated their agreement or otherwise with eight different statements, such as "Maths is boring", and "There is a correct way to do any maths

problem". At the conclusion of the workshop the participants were asked to revisit their responses and note whether or not any of their answers were 'challenged' by the workshop. Throughout the workshop, the facilitator (author of paper) presented a number of these statements, discussed them and engaged the participants in activities designed to counteract the 'myths'.

Subsequent sessions were organised around areas of 'need', including algorithms, tables and mental computation and fractions. Each session followed a similar format, which included provision of some information, hands on activities and games and provision of resources, including follow-up reading and web sites. The sessions were of an informal nature and interaction was encouraged. In a recent session on fractions, for example, participants were asked to use a digital camera to go outside and take a photograph of something in the environment that could be used to stimulate conversation about fractions (see Figure 3). The photos were then shared with the group, leading to a discussion about fractions being more than a numerical representation of a numerator and denominator. Chocolate was used to demonstrate division of fractions (Clarke, 2006), and an interactive fraction game using a fraction wall was used to demonstrate equivalent fractions (Clarke, Roche & Mitchell, 2008).

As previously mentioned, the topic of tables and multiplication facts was identified as an area of 'need' and so perhaps not surprisingly, along with calculators, this topic stimulated the most discussion among participants. This is consistent with parental concerns identified by Goos and Jolly (2004), in that "their children were not learning tables by rote" (p. 283). According to Warren and Young (2001), a belief that mathematics is best learnt by drill and practice can undermine mathematics reform so it was important to address this in the context of the workshop. Similarly Marshall and Swan (2010) identified that parents requested advice in how to help children understand and learn multiplication tables and expressed disappointment that their children were not fluent with their tables. It seems that this concern is not limited to Australia, as Civil et al. (2008) also found that memorisation of multiplication facts was one of the issues parents raised and particularly commented on it as not receiving the emphasis it did in their own schooling. Parents revealed that their personal experiences with learning tables involved 'chanting' and rote learning, but many acknowledged the limited success of this and were keen to explore alternative approaches. Similarly, parents were more receptive to the wide use of calculators when they could see their use as a tool in facilitating their children's mathematical understandings, rather than just as a device to get an answer.

As reported in Muir (2011), attendance numbers at the workshops varied, but those that did attend actively participated, asked questions and provided positive feedback, with one parent expressing "that was fantastic". Promotion through the school newsletter, personal invitations, provision of afternoon tea and two different time-slots helped to contribute to an increased attendance rate.

In summary, the response to the Maths Club has been very positive and senior staff and parents were keen to see it continue. The following testimonial from a parent shows the potential it has for making a difference:

> I have been attending the maths club and found it to be both informative and fun. It is a great opportunity to get together with other parents with similar concerns. As a parent I struggle to remember how to do the maths I did at school, let along know how to help my children with their maths, so it has been very helpful to find out how maths is taught today and learn useful strategies that I can use to help my children with maths. Working together with other parents is a lovely way to learn and using the materials provided is also a good way to learn; I have been able to use these activities at home with my children. As my children progress through school I want to know more about algebra and other mathematical topics that they will learn so I look forward to be able to continue to attend the maths club.

Conclusions and Implications

Consistent with other research (e.g., Civil, 2001; Sheldon & Epstein, 2005), the parents that were involved with these projects showed that they were willing to participate in their child's mathematical education, but needed more information about current mathematical practices and the rationale behind these practices. Furthermore, as Civil (2001) found, and referred to in Muir (2011), parents are appreciative of the opportunity to engage in discussions about mathematics teaching, enjoy doing mathematics, are keen to improve their own mathematical content knowledge and want to gain a better understanding of reform mathematics.

As advocated elsewhere (Muir, 2009), if schools and teachers are serious about establishing effective working partnerships with parents, then they need to empower parents to enable them to contribute to their child's numeracy development. This can be achieved through 'at home' programs, or through initiatives such as the Maths Club.

Projects such as IMPACT and Ocean Mathematics have highlighted the potential that parental involvement can have improving pupil achievement and attitudes. While Desforges and Abouchaar (2003) caution that it is impossible to describe the scale of this impact, they also make the point that this does not mean that the interventions do not work. They are also agreed that parental involvement overall has a significant effect on children's achievement and that this continues to have a significant effect through the age range. While the projects undertaken in this paper are relatively new, documentation of other similar programs and workshops in the literature have indicated success with programs that are ongoing and involve a number of different approaches. Civil (1998), for example, has extended parental involvement in a BRIDGES program, to household visits and occupational interviews – all designed to bridge in-school and out-of-school mathematics and to acknowledge the contributions that parents can make to their children's mathematical education. Pritchard (2004) also found that parents had plenty of ways in which they could support mathematics learning in out-of-school environments. Further study could be conducted in this area.

The influence of parents' prior learning experiences on mathematics and mathematics education is another area in which further study is needed. Parents who participated in the projects, and particularly the Maths Club, commented on how their own experiences as learners of mathematics influenced their approach to helping their children. Many indicated that they had negative feelings about mathematics, and attributed this to the way in which they were taught, particularly at high school. It seems that, similar to parents in other contexts, they were educated by school practices that emphasised memorisation of facts, computation and sometimes problem solving (Civil, et al., 2006). Parental programs and workshops, therefore, need not only to address mathematical content, but also to consider addressing the affective domain and look at increasing parents' confidence and motivation to undertake mathematics.

Civil's work also emphasised the need to develop two-way dialogue in which parents contribute their ideas and uses of mathematics in their everyday life and to view parents as intellectual resources. Future sessions and directions that may develop out of these projects, therefore, will take these recommendations into account, and will avoid the tendency to be one-way transmissions of information and materials from school to the parents. Instead provision will be made to provide opportunities for their beliefs, ideas and concerns to be heard (Civil, 1999).

Future directions for the projects include engaging parents in the exploration of mathematical topics that their children are likely to be experiencing in school and to help them strengthen their own understanding of mathematics (Civil, 2001). In addition, other

models designed to increase parental participation may also be explored. For example, Civil, Quintos and Bernier (2003), describe a model in which parents observe mathematics lessons in the classroom and engage in dialogue about mathematics education reform. It appears that this approach is something that could be explored in other contexts.

As parents become more informed about mathematics education issues and more exposed to sound approaches to mathematics teaching and learning, will they become more active advocates for a quality mathematics education for all children? (Civil, 2001) In the projects reported on in this paper, informing parents was done through creating the opportunity for them to engage in information sessions, and in numeracy related activities with their children in the home environment. Parents responded positively, with many questioning their own experiences of mathematics education: "How come we were not taught this way when we were in school?" It is hoped that the documentation of the programs in this paper will assist teachers and educators with recognising the importance of parental influences and the difference they can make to their child's education.

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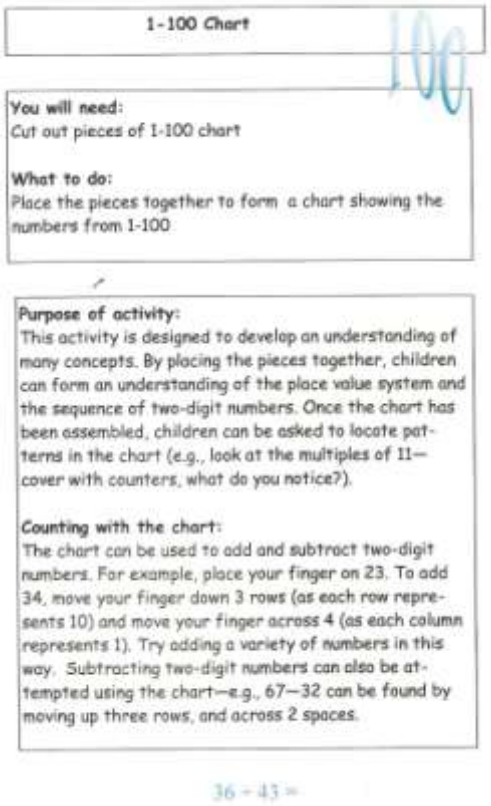

1-100 Chart

You will need:
Cut out pieces of 1-100 chart

What to do:
Place the pieces together to form a chart showing the numbers from 1-100

Purpose of activity:
This activity is designed to develop an understanding of many concepts. By placing the pieces together, children can form an understanding of the place value system and the sequence of two-digit numbers. Once the chart has been assembled, children can be asked to locate patterns in the chart (e.g., look at the multiples of 11—cover with counters, what do you notice?).

Counting with the chart:
The chart can be used to add and subtract two-digit numbers. For example, place your finger on 23. To add 34, move your finger down 3 rows (as each row represents 10) and move your finger across 4 (as each column represents 1). Try adding a variety of numbers in this way. Subtracting two-digit numbers can also be attempted using the chart—e.g., 67—32 can be found by moving up three rows, and across 2 spaces.

36 + 43 =

Figure 1. Example activity

Figure 2. Child using giant calculator

Figure 3. Fraction photo taken by parent

Appendix A

Numeracy at home feedback sheet

Name of activity: Child's name:

Date:

How many times did you and/or child complete the activity? ……..

This activity was appropriate for my child	Agree	Disagree
My child enjoyed completing the activity	Agree	Disagree
The instructions were clear	Agree	Disagree

What mathematical understandings (or misunderstandings) did your child reveal when participating in the activity?

Do you have any other comments or questions about the activity?

Thank you for taking the time to complete this feedback.