Effective Mathematics Strategies *for Pre-School Children with Autism*

HUI FANG HUANG SU, LEANNE LAI and **HERMINIA JANET RIVERA** look at adjusting the teaching of mathematics to cater for young students with autism. They report on a project that helped students link unfamiliar concepts to what they already know. Many of the ideas could be applied to teaching young mainstream students.

Introduction

Autism is a neural development disorder which impairs one's ability to socialise, communicate, process sensory information, and those with autism experience restricted interests and repetitive behaviours. These signs all begin before three years of age and the child may have difficulty with organising their responses, with inhibition of repetitive behaviors and interests, and are more likely to have associated leaning difficulties (McConachie & Diggle, 2006). The Centers for Disease Control in the USA (2007) reports that as many as one in every 110 people has autism. In Australia, there has been an increased focus on autism in recent years, to the point of it becoming a Federal election issue. Autism has been portrayed as a crisis, an epidemic, a puzzle, an over-diagnosed condition, a struggle and a financial burden for families, a scientific curiosity, as well as the root of special and extraordinary talents (Annear, 2009). Australia is similar to the rest of the world in terms of the issues it faces in Special Education, specifically with the Autism condition (Forlin, 1999), but it also has its own set of challenges. Each State and Territory has their own jurisdictions and interpretations of the Federal perspective. Under the Australian Constitution, States have responsibility for education. It is clear that no one school can possess all the skills, understanding, and knowledge, nor a complete range of programs and resources to ensure all students achieve to their maximum potential (Forbes, 2007).

Autism education

Many aspects of the autistic child's difficulties start gradually during the first two years of the child's life. Autistic children frequently pose considerable behavioural challenges and they need help to develop early skills in establishing attention, imitation of others, communicating interest and meaning as well as immediate wants, understanding the language of others, getting on with and enjoying the company of other people, tolerating change, and so on. This broad agenda has spawned many approaches to early intervention (McConachie & Diggle, 2006). Early intervention programs are highly associated with positive outcomes and it has been found that some types of intervention appear to reduce the debilitating impact of autism (National Research Council 2001; Hurth, Shaw, Izeman, Whaley & Rogers, 1999). Designing teaching strategies that support the development of young children with autism is a challenge for both teachers and administrators. The National Research Council (2001) noted that research on strategies for teaching mathematics to students with autism is limited. In their study, Brown and Snell (2000) identify mathematics as a key area of academic instruction for students with multiple and severe disabilities, including autism. Butler, Miller, Lee and Pierce (2001) found in their literature review of mathematics instruction that students benefited from interventions emphasising frequent feedback and explicit instruction.

The development of Project MIND — Math Is Not Difficult

In 1988, Hui Fang Huang "Angie" Su, created a unique program utilising innovative strategies and instructional models designed to get all students, including special needs children, and teachers of all ability/grade levels excited about mathematics through mathematics games, stories, poems, songs, arts, puzzles, mental maths activities, and competitions for all children (Su, 2002). Students who were exposed to the MIND strategies, especially at the elementary level, obtained impressive test results (Annenberg, 1999). According to the Annenberg Challenge Report (1999), "low-income schools all participate in Project MIND (Math Is Not Difficult), a pilot program that could become a model for maths instruction throughout the county. Not only teachers but administrators, secretaries, nurses, cafeteria workers, and teacher's aides had all attended 30 hours of training in Project MIND strategies". The report, an independent evaluator of the Project MIND strategy, clearly supported the effective use of the strategies for all learners.

Using Project MIND with autistic children

The study indicated that students with high-functioning autism indicated an increase in knowledge of mathematical aptitude. To investigate the effectiveness of Project MIND with the autistic population, in 2005 and 2006, Su took her teaching methodology, using an exploratory study with quasi-experimental pre-/post-plus control group design, to a South Florida pre-school serving children with autism. The detailed background of the project was described in an article by Su, Lai and Rivera (2010). The purpose of the exploratory study was to identify the effective uses of instructional strategies that will impact students' learning. Instruction consisted of both direct and embedded instruction derived from the Project MIND curriculum (Su, 2002). For the purpose of this study, one autistic class and one integrated class were randomly assigned to a study group. The other two classes served as the control group. In all, 25 students with autism and 10 typically developing peers participated in the study.

Both the study and control groups were given pre- and post-mathematics achievement tests using subtests from the Hawaii Early Learning Profile (HELP) which assesses a student's mathematical reasoning and problem solving, and the Bracken Basic Concept Scale – Revised (BBCS-R), which assesses students' knowledge of the language of mathematical concepts. In addition to a pre- and post-test comparison, students were assessed (prior to intervention) on their cognitive and visual-spatial abilities. Cognitive abilities were assessed using the Mullen Scale of Early Learning (MSEL), a comprehensive individually-administered measure of cognitive functioning. Visual-spatial abilities were assessed using the Beery Developmental Test of Visual Motor Integration (VMI). The VMI and the MSEL were used to identify the relative effects of these variables on acquisition of knowledge of mathematical concepts (Su, Lai & Rivera, 2010).

The study results indicated that students with high-functioning autism were able to increase knowledge of mathematical concepts when exposed to MIND. In addition, the study revealed significant differences between the study and control groups in results of the MSEL and VMI (Su, Lai & Rivera, 2010).

Strategies for young children with autism

Based on the results of the study described above, our work with the pre-kindergarten and kindergarten students challenged us to use familiar concepts while building new bridges to the unfamiliar and abstract. The best way to begin building the base-ten concept is to start with the everyday relationships, objects and terminology that students know, such as fruits and vegetables, candies, classroom items, toys, animals and people (Su & Su, 2004). Children develop relationships early on. They learn quickly to play and work with each other. Soon, children form 'best friend' relationships that extend from classroom to play and vice-versa. As children play within classroom areas, they often work in pairs, groups and teams to play, build, create and solve problems related to the tasks at hand. In the same way, Su (2002) created mathematical 'best friends' to teach higher-level concepts for solving mathematical problems. Children learn that 1 and 9, 2 and 8, 3 and 7, and 4 and 6 are 'best friends'. They also learn that 5 is best friend with its twin and that 0 and 10 are best friends (Su & Su, 2004).

The best friends concept helps to perform addition of multi-digit numbers, subtraction, multiplication, division, fractions, and other number operations such as powers and roots. Besides best friends, complementary numbers were introduced, such as adding to powers of a base; for example, 98 and 2 add up to 100, which is square of 10. The concept of best friends is easily extended to other numeration systems (Su, 2003).

Pre-training for teachers

Prior to implementation of mathematics instruction, all teachers received instruction and training on using the Project MIND approach (Su, 2002; 2003). Classroom teachers participated in after-school training sessions for five months, from September through January, and received frequent coaching visits and support by project staff to trouble shoot, provide resources, and to ensure the curriculum was properly implemented. The teachers of the intervention class practiced activities for students in a systematic fashion. They learned the concepts and activities during training and immediately put them into use with their students the next day (note: graduate students, parents and project staff may assist in creating and preparing the materials for the teachers). The materials consisted of poster boards for large number tiles, construction papers for coloured number tiles and number strips, various objects to use for counting and 'object grab game', number cards for various number games, and training manuals by Su (1988).

For students in the study group, systematic instruction in mathematics using strategies based on the Project MIND approach was implemented for a period of three months. Systematic instruction was provided using both direct and embedded instructional strategies for teaching mathematical concepts such as number sense and numerical operations.

In one of the activities, the students paired themselves up with their best number friends (0 + 10, 1 + 9, 2 + 8, 3 + 7, 4 + 6, 5 + 5, 6 + 4, 7 + 3, 8 + 2, 9 + 1, 10 + 0), making early connections to addition and subtraction number concepts, as well as building pre-algebraic thinking (see Figure 1). The strategies and activities used by the teachers of the intervention group are described in detail below:

Figure 1. Best friend number tiles.

Games using number tiles

The teachers arranged 11 chairs at the front of the classroom and placed the large number tiles in order from 0–10 on the chairs. The number tiles were colour coded; for example, 0 and 10 are in red, 1 and 9 are in green, 2 and 8 are in yellow, and so on.

During maths time, 11 students were placed in the 11 chairs at the front of the classroom and the rest of the students were seated on the floor in front of the chairs. Each student was given a large number tile. Each number tile was attached to a string so that the tiles could be hung around the students' necks. The lesson started by the teacher posing a problem.

Teacher: I am going to name a few pairs of best friends. See if you could name another pair of best friends for me? Four and six are best friends. Three and seven are also best friends. Could you tell me why they are best friends?

Students: They have the same colour.

Teacher: Could you name another pair of best friends and then tell me why?

Students: Two and eight because they have the same colour.

Teacher: Not only do these best friends have the same colour, together they make ten, or they also add up to ten! You see: six and four; one and nine; two and eight; three and seven; zero and ten. And the other way around: four and six; nine and one; eight and two; seven and three; ten and zero, they all make ten. Five is so independent, so he is his own best friend!

Teacher: Let's play a game. I am going to name a number and you will tell me who that number's best friend is. Who is seven's best friend?

Student: Three.

Teacher: Why are four and six best friends?"

Students: Because they add up to 10. Because they make ten.

Materials used for this activity were simple: large number tiles were drawn and placed on colour coded backgrounds. The number friends had the same colour backgrounds and the tiles were placed on a string 'necklace' so that the children became living numbers. When the children first observed the numbers, they may not have learned to count or recognised the number symbols. However, they knew their colours. Through the activities, the children noticed the relationships among the colours. They noticed that 6 and 4, 0 and 10, 1 and 9, 3 and 7, and 5 and 5 shared the same colours. This activity helped the students to conceptualise several mathematics concepts, such as number identification, counting, addition, subtraction, pre-algebra thinking, number before and after, and the base 10 concept.

The number strip game

To maintain students' continued interest in learning the base 10 concept, the Number Strip Game was introduced. A stack of strips (12 cm × 40 cm) with random problems such as 2 + ____ = 10; ____ + 7 = 10; ____ + ____ =10; 4 + ____ = 10, was made for this activity. The teacher showed a number strip, and asked, "What number is missing?" (see Figure 2). The student response might be, "One, because one is nine's best friend and together they make ten."

Figure 2. What number is missing?

Su (1988) suggested a variety of ways that the game can be played. The following variations were "played" and tried with the students in our study:

1. Teachers could make large number tiles like the ones showed in Figure 1 and have students wear the large number tiles. Arrange 11 chairs in a row and have best friends sit next to each other when prompted: 3 sits next to 7, 8 sits next to 2, etc.
2. Teachers could use post-it notes and write a few sets of random numbers depending on how many students in the class. Then, each student wears a post-it number. This format allows the students to see the possibilities of having many sets of 'best friends' (number pairs adding up to ten) as long as they are number buddies. The teacher may allow best friends do things together throughout the day including lunch time buddies, bathroom buddies, activity centre buddies, etc.
3. Teachers could make large number tiles and stack them and use them as number cards; scatter them on the floor and play memory game; lay them in the front of the blackboard as visual aids for number sequencing; display them one tile at a time for counting. The possibilities are endless. It all depends on how a teacher chooses to utilise the numbers.
4. Teachers could make a smaller version of the large number tiles and insert them in a plastic name case or students could wear them. This format is more manageable than the post-it note numbers. The numbers could be reused and students could be assigned different numbers each day.

Figure 3. Missing best friend game.

Early algebraic thinking activities from the best friend concept

Described below are some of the final activities that led to the addition, subtraction, and algebraic thinking concepts. When these activities were introduced, students were used to the 'best friend' concept and were able to participate in the activities without much prompting. At this point, they were great observers and problem-solvers. They were also used to working in teams.

Game 1

Students work in pairs. Have the students create number sentences using "?", "+", and "=" and the best friend concept. For example, "? + ? = 10". The students will soon discover that they are actually looking for best friends and that the best friend pairs make 10.

Game 2

Four students work as a team. Use the "+" and "=" sign to lay out a number sentence with a missing variable (see Figure 3). For example: 5 + ? = 10; ? + 8 = 10. The first person to complete the number sentence correctly gets to make the next problem.

Game 3

Using the same set-up for addition, this time ask the students to make a number sentence starting with the number 10 and put a subtraction sign after 10. For example: 10 – ? = 3; 10 – ? = 6. Students will quickly realise that the missing number and the sum are best friends (sums to 10).

Conclusion

The initial findings from our study will help reform the way special and general educators provide mathematics instruction to young children with autism as well as children with other disabilities through Project MIND. Currently, there are no such studies being done by any groups. We would like to expand our study to include older students with autism, and those with concomitant intellectual disabilities in our future studies.

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