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Developing Numeracy in Young Adults with Down Syndrome: A Preliminary Investigation of Specific Teaching Strategies

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Abstract

This article reports the implementation of a specific teaching program (STP) to improve the numeracy skills (place value) of a cohort of young adults with Down syndrome. The STP was based on a range of teaching strategies that research had shown were effective across various groups who have difficulties with numeracy learning.

The participants were selected from a post school literacy program at the University of Queensland (Moni & Jobling, 2000). The twelve participants in the program were assessed using the Booker Profiles of Mathematics (Booker, 1995) and divided into three groups based on these profiles. The group chosen to participate in the STP showed the prerequisite skills in number recognition and counting needed to learn place value *but had no prior knowledge of the concept. The other groups participated in a series of game sessions and did not receive the STP.*

The data comprised pre and post testing, field notes, classroom observations and family histories. The five participants in the STP showed improvements in their skill acquisition, including developing some understanding of place value*.*

Our findings demonstrate that individuals with Down syndrome can learn basic numeracy concepts but due to the small sample size more research is required.

There is a commonly held educational perception that not everyone can learn numeracy skills. Elliot and Garnett (1994) expressed concern about the acceptance of this perception in society, especially among parents, as this negativity would never be tolerated about literacy; nevertheless, this attitude has persisted in texts for special educators (Massey, Noll & Stephenson, 1994; Rosenberg, Westling & McLeskey, 2011) where it has been suggested that numeracy for some students, including those with intellectual impairment, should be confined to developing functional skills for everyday life.

These attitudes persist due to the limited knowledge both about the numeracy abilities of adults with Down syndrome and how these abilities can be developed over time. In addition, there is limited information on the effect of specific teaching strategies on this development (Leonard-Giesen, 2009). Other research has suggested that the development

of mathematical understanding relies on effective pedagogy based on knowledge of how students develop an understanding of mathematical concepts rather than on traditional teaching which is often mostly teacher centred (Lowrie, Bobis, & Mulligan, 2008). With this orientation towards how students learn, the characteristics of learners with Down syndrome, such as the degree of intellectual impairment, can be taken into account (Selikowski, 1997). Students with Down syndrome benefit from being taught abstract mathematical concepts with practice and variation using concrete materials over time (Buckley, 2007).

Added to their intellectual impairment, learners with Down syndrome may also have sensory impairments (vision and hearing) that could contribute to their generalized language learning delay and affect their numeracy learning (Hammond & Millis, 1996; Lorenz, 1998; Tiens, 1999). Correlations between language learning delays and numerical ability have been found by Nye, Clibbens and Bird (1995) while Buckley (2007) and Horstmeier (2004) stated that generally their numeracy skills were approximately two years behind their literacy skills.

The Development of Research in Aspects of Numeracy and Down Syndrome

There have been limited studies of numerical abilities of individuals with Down syndrome. Studies by Brown and Deloache (1978); Cornwall (1974); Gelman (1982) and Gelman and Cohen (1988) suggested that children with Down syndrome showed no understanding of the principles of counting, and merely repeated what they had learned by rote. However, studies by Caycho, Gunn and Siegal (1991), Nye, Clibbens and Bird (1995), Porter (1999) and Nye, Fluck and Buckley (2001), have suggested that children with Down syndrome can learn to count, but their ability to learn these skills is related to their language development skills. Bird and Buckley (2002) also suggested that students with Down syndrome still failed to reach a competent level of numeracy skills even though they had reached a competent level in their literacy skills.

Other researchers have found that children with Down syndrome are capable of learning to complete addition tasks by using the strategy *counting all* (Buckley & Sachs, 1987; Irwin, 1991). Faragher and Brown (2005) found that adults with Down syndrome learned numeracy skills effectively when they were taught within the context of the everyday situations in which the skills were used. Turner, Alborz and Gayle (2008) discussed factors that may influence the development of literacy and numeracy skills in young people with Down syndrome from primary to secondary and post school settings and found that mainstream schooling had a positive effect on academic attainment of these young people. Thus it may be, as some researchers have found, that deficits in numeracy "more likely reflects a lack of teaching rather than a lack of ability" (Tiens, 1999, p. 5). Porter (1999) shared this view with Bird and Buckley (1994) arguing that "…with good teaching there is no reason to predict a level that cannot be surpassed…" (p. 65). A challenge also came from Shepperdson (1994) who concluded from their study of the reading and numeracy abilities of teenagers and young adults with Down syndrome who were born in the sixties and seventies, that "…if they are taught, individuals can learn." (p. 101).

This article reports on the development, implementation and evaluation of a STP designed to develop the numeracy skills, specifically the concept of place value, of a group of young adults with Down syndrome. The STP was designed to meet their identified learning needs in numeracy by using the strategies of explicit teaching, repeated practice and the use of concrete materials. Games sessions were used to help the participants practise what they had learnt.

Aims

The aims of this study were to explore the current body of knowledge and research about the numerical abilities of individuals with Down syndrome and to develop, implement and evaluate a program to teach a basic number concept, *place* value, to a group of young adults with Down syndrome. The study drew on three bodies of knowledge: the development of numeracy skills in typically developing children; knowledge of effective teaching strategies for students with learning difficulties; and knowledge of teaching and learning for individuals with Down syndrome.

This study addressed three questions:

1. What are the numeracy abilities of a group of young adults with Down syndrome?

2. What kind of specific teaching program would meet the needs of the individual students?

3. How effective were the strategies of explicit teaching, repeated practice and use of concrete materials and games in teaching the targeted students?

Materials and Methods

The key concept of understanding of *place value* in the numeracy development for the participants was investigated. This study used the four specific teaching strategies of explicit teaching, repeated practice and use of concrete materials and games in teaching the targeted participants. The four strategies were embedded in the STP.

A single subject case study design was used to investigate the effectiveness of explicit teaching of *place value* concepts to a group of young adults with Down syndrome. The purpose of single subject research is to discover the effects of some type of intervention on an individual (McCormick, 1995). This design model can demonstrate the effectiveness of an intervention better than many statistical approaches because the subject's achievements can be directly attributed to the intervention. In this study, each of the participants formed an individual case study (Gay, 1996). As only five participants were selected and targeted for the STP, it was decided that the most useful information would be achieved following this case study model as this would involve in depth analysis of the achievements of each student.

To select participants for the study and to develop the STP at an appropriate level within the numerical development of the participants, the Booker Profiles of Mathematics (Booker, 1995) were administered as a pre test to the full cohort of students attending a post school literacy programs for young adults (Moni & Jobling, 2000). Individual profiles of each student were developed from the Booker Profiles of Mathematics (Booker, 1995) and these were used to match the learner's profiles to the STP.

During both assessment and teaching sessions, qualitative data in the form of observational notes were also collected. These data were used to enhance the data collected from the Booker Profiles of Mathematics (Booker, 1995).

Participants

The twelve participants (4 females and 8 males) for this study were young adults who have Down syndrome (aged 17 years, 2 months to 21 years, 2 months) and had completed or were completing their last year of secondary schooling.

Procedure

The procedure for this study is presented in two parts. The first part comprises the assessment to place participants into different groups for intervention, and the second part describes the development and implementation of the STP and its related teaching strategies.

Assessment and Group Selection of Participants

Whilst most teachers may not have access to these assessments, in designing any intervention, teachers need to recognize the limitations demonstrated by individuals with Down syndrome in their receptive and expressive language skills. In this research study, these skills were formally assessed to guide the development of the STP.

Assessment Tools

Two standardised assessment tools were used: (1) the Peabody Picture Vocabulary Test – Third Edition (PPVT-III, Dunn, Dunn, & Williams, 1997), and (2) the Expressive Vocabulary Test (EVT, Williams, 1997).

The PPVT-III (Dunn et al., 1997) measures receptive vocabulary attainment, and is a screening test of verbal ability. The age equivalent score for receptive language was used in this study because an understanding of the participant's receptive language is essential for

teachers to know when planning the language content of a teaching project.

The EVT (Williams, 1997) measures expressive vocabulary knowledge. The age equivalent score for expressive language was used in this study because the participant's responses to questions rely on their expressive language and it is important to understand an individual's strengths and weaknesses in this area before a teaching program can be implemented.

As well as investigating the participants' language abilities, it was necessary to understand the numerical abilities of the participants before developing the STP. A number of standardized tests are available which give age equivalent or grade level equivalent scores but as Westwood (1997) argues:

> …standardized tests are of rather limited value for programming purposes since they do not yield a comprehensive picture of a student's broad range of knowledge and skills. (p. 170)

It was, therefore, decided to use a tool in which individual performance is presented as a profile of numeracy skills rather than a normative score as this provides a broader range of information related to the participants' numeracy knowledge and skills. The Booker Profiles of Mathematics (Booker, 1995) is an extensive individual assessment tool and has two separate sub-tests, one for numeration and one for computation. The numeration test compiles a profile for each aspect of numeration: the use of materials, language and symbols and being able to move between them; the understanding of *place value*, sequencing, comparison and counting. It contains subsets for single digit numbers, two digit numbers and up to seven digit numbers. Only the first two sections of the numeration test were used in this study: single digit numbers and two digit numbers.

Booker (1995) claims that "these tests not only profile an individual's understanding and skill but also provide the basis for developing an individually tailored program to consolidate this knowledge as a foundation for using and applying mathematics." (p. i of manual). It was on the basis of this profile that the participants were separated into groups for this study.

Lastly, the personal background data, including family and educational history as well as major health problems were collected using the files kept on the students who had participated in the DSRP longitudinal study (Jobling & Cuskelly, 1998).

Results of Assessments

As can be seen from Table 1, the PPVT-III scores ranged from 4 years, 2 months to 11 years, 3 months and the EVT from 3 years, 10 months to 6 years, 8 months. These results align with previous research that demonstrates that receptive language is more developed than expressive language among persons with Down syndrome (Horstmeier, 2004) and support the correlation between language development and numerical attainment reported by Rahman (2005). In the context of developing the STP, this meant that the researcher needed to be mindful of the language used in explanations of numeracy concepts and needed to check for understanding of the participants as they may not necessarily have had the means to ask for assistance if they did not understand a concept.

Table 2 shows the data from the Booker Profiles of Mathematics (Booker, 1995). The different sections of the test are shown across the table and the total possible score for each section is given in brackets. Group A is represented by the first 5 students listed, Group B by the next three students italicized and Group C the last four students shaded darkest.

The table shows the number of correct responses each student achieved in each section. The first six sections of the test deal with the ability to recognize numbers and manipulate them using language (saying, reading and writing numbers in words), symbols (numbers) and materials (base 10 materials and paddle pop sticks to represent numbers). The other sections of the test investigate students' abilities to understand the concept of *place value*, sequencing numbers, comparing the size of numbers, counting (both forwards and backwards and by ones, twos, tens, etc.) and the ability of students to round numbers to the nearest 10, 100, etc.

Participants were divided into three groups on the basis of results from The Booker Profiles of Mathematics (Booker, 1995). Those selected for Group A had good counting and number rec-

Table 1. Participant Summary

Group	*Participants*	*CA Mean*	*CA Range*	*PPVTIII Mean*	*PPVTIII Range*	*EVT Mean*	*EVT Range*
A	Julie David Tom Edward Kylie	19y 2m	17y 2m to 20y 9m	7y 5m	5y 8m to 8y 7m	5y 6m	3y 10m to 6y
B	Nancy Peter Jim	20y 2m	18y11m to 21y 2m	8y 9m	6y 11m to 11y 3m	6y	5y 10m to 6y 8m
C	John Kelly Jack Pat	19y 3m	18y 9m to 19y 11m	6y	4y 2m to 8y 7m	4y 9m	4y 1m to 5y 10m

ognition skills. It can be seen from the scores in the counting column reported in Table 2 that most participants in Group A demonstrated an ability to count. The questions the participants got incorrect were counting in tens and counting backwards. One participant scored one and another scored zero; however, both participants demonstrated their ability to count in other questions on the test and it was considered appropriate to include these two students in the target Group. Those selected in this group had mastered counting skills but had no understanding of *place value* as can be seen from Table 2, where all the participants in Group A, except Tom, scored zero on *place value*. Tom was able to answer some questions on *place value*. However, he made no distinction between the ones and the tens in the materials he used although he managed to arrive at the correct answer in some of the simple questions. Hence, the target Group had the prerequisite skills to learn about *place value*, but no existing concept of *place value*.

The participants who were selected to participate in Group B had both good counting and number recognition skills as well as the beginnings of an understanding of the concept of *place value* (refer to Table 2). Their scores across the first eight sections of the test were higher than those of Group A. However, they were unable to apply this knowledge to skills such as counting by tens beyond 100 or increasing or decreasing a given number by ten. This is evidenced in their similar scores to Group A on the comparison and counting sections of the test. These participants were not selected as the target Group for the STP as they had some concept of *place value*.

The participants in Group C did not have a strong knowledge of counting nor number recognition (refer to Table 2). Many of the members of this group did not score in many sections of the test. They would sometimes miss numbers in the count string or not show one-to-one correspondence when counting. It was determined that these participants did not have the necessary prerequisite skills to progress onto learning about *place value* concepts and thus were also not selected as the target Group for this study.

Development and Implementation of the Specific Teaching Project (STP)

Development of the STP

The STP to teach *place value* was developed using the participants' skill levels and was based on assessment results to find the participant's level of learning. (see Tables 1 and 2). From the literature, explicit teaching strategies (Maccini, Mulcahy, & Wilson, 2007; Mercer, Jordan & Miller, 1996; Munro, 2000; Smith & Gellar, 2004) were employed with repeated practice (Impecoven-Lind & Foegen, 2010; Pagliano & Gillies, 2009, Westwood, 1997;

Table 2. Individual Test Results for Booker Profiles of Mathematics

Name	*Materials to Language (5)*[1]	*Language to Materials (4)*	*Materials to Symbols (4)*	*Symbols to Materials (4)*	*Symbols to Language (4)*	*Language to Symbols (4)*	*Place Value (4)*	*Sequence (10)*	*Comparison (3)*	*Counting (4)*	*Rounding (1)*
David	3	2	1	2	1	2	0	3	1	1	0
Edward	3	1	1	2	2	1	0	3	0	2	0
Julie	3	2	1	2	2	2	0	1	0	2	0
Kylie	2	1	3	1	4	3	0	6	1	0	0
Tom	3	2	2	4	4	4	3	5	1	2	0
Nancy	5	4	3	4	4	4	4	8	0	2	0
Peter	3	4	4	4	4	4	0	6	1	3	0
Jim	2	3	4	4	1	2	4	7	1	2	0
Kelly	1	0	0	0	1	1	1	0	0	0	0
Jack	1	0	0	0	0	1	0	0	0	0	0
John	0	0	1	0	0	1	0	2	0	0	0
Patrick	1	1	0	3	2	2	0	3	1	0	0

The number in brackets shows the total number of questions in each section.

van Kraayenoord & Elkins, 2009). The use of concrete materials (Booker, 2000a; Booker & Windsor, 2010; Booker, Bond, Sparrow & Swan, 2010; Mercer, Jordan & Miller, 1996; Westwood, 1997), and the use of games (Booker, 2000b; Booker et al. 2010; Westwood, 1997; Westwood, 2004) were employed in the STP. To ensure participants were given the best opportunities to learn, short instructional periods in a familiar setting (Ashman & Merrotsy, 2009) were considered appropriate. The sequential stages of the STP and the teaching and game sessions are outlined below in Table 3. There were nine weekly sessions of specific *place value* teaching for Group A and nine games sessions for all participants. After nine weeks, this was followed by the post test again using the Booker Profiles of Mathematics (1995).

Table 3. Stages of the STP

Stage of Project	*Description*
Pre Tests	All participants were assessed using the Booker Profiles of Mathematics prior to being organised into groups for the STP
Teaching Sessions: Group A Only	There were nine teaching sessions in all. Each session was 70 minutes in total, 40 minutes before morning tea and 30 minutes after. Participants in Group A were divided into two smaller groups: three attended Wednesday and two attended Thursday mornings.
Games Sessions	There were nine game sessions in all. All five participants in Group A participated in the games session for the first 50 minutes on Friday mornings. After morning tea, the other two Groups, B and C, each attended a 50-minute games session.
Post Tests	All participants in Groups A, B and C were assessed using the Booker Profiles of Mathematics one week after the teaching sessions were complete.

Implementation of the STP

Each morning the teaching session was divided into two by a morning tea break. The time frame was designed to take into account difficulties with sustained attention as identified by Rosenberg, Westling and McLeskey (2011) and Ashman and Merrotsy (2009). In addition, it was assumed the learners would have better concentration in the morning. In the first 40 minute session of the morning new material was introduced (Goodman, 1996) and then consolidated in the second 30 minute session.

Table 4 shows an outline of the concepts taught each week, the resources and strategies used in each explicit teaching session. The program focussed on repetitive and concrete teaching methods. During each teaching session, the participants received explicit instruction on *place value* concepts. They used concrete materials (base ten blocks), various worksheets from Silbey (1989) and received individual tutoring in learning these concepts. Sessions were developed sequentially, reflecting the considered opinions of researchers that the nature of learning numeracy is sequential (Booker et al. 2010; Munro, 2000; van Kraayenoord & Elkins, 2009).

Games Sessions

All participants (Table 1) took part in a games session on Friday morning. Booker (2000b) suggested that games are an effective teaching tool and can both enhance the learning that has previously been taught in the classroom and be used to introduce new concepts to be learnt. Moreover, as stated by Booker (2000b) "they contribute to the development of knowledge while having a positive influence on the affective or emotional component of learning situations." (p. 1). Thus Groups A, B and C attended the games sessions to ascertain if there were any benefits to their numeracy ability as measured by the Booker Profiles of Mathematics.

Table 4. Development and Sequence of Strategies

Week	*Concepts Taught*	*Games*	*Strategies*
1	Recognizing numbers 1–20 in words and numbers. Recognizing the date in words and numbers	Number recognition games: Number play	• Teacher directed discussion of each concept to engage students prior knowledge • Repetitive activities: e.g., the date was written on the board each session and discussion about different ways of writing the date and what the numbers meant was the first activity of each lesson. • Explicit teaching of concepts followed by teacher directed activities followed by independent practice • Regular review activities throughout the program • Games sessions linked to previous content taught
2	Recognizing numbers from 1–100 using materials	Counting games e.g., Snakes and ladders	
3	Repeat week 2	Bingo: One more/less	
4	Counting Board: counting in 10s starting from any number	Bingo: Ten more	
5	Review of counting in tens from any number. Finding ten more or less than a number	Computer games	
6	Review of previous concepts Introduction of decreasing numbers by ten	Ten less bingo	
7	Ordering numbers Introduction of hundreds	Using MAB and dice, make largest number: throw dice three times then using ones, tens and hundreds make largest number possible.	
8	Three digit numbers	Card Game: make largest number from three chosen cards; extra points for stating ten more than number.	
9	Review of two and three digit numbers.	Assessment	

Ideas for the games were developed from The Maths Game, Booker (2000b).

During each games session, the participants played games specifically designed to reinforce the concepts taught to Group A during the previous lessons that week. For example, when participants were learning to increase or decrease numbers by ten, the game played was *10 more bingo*. When a number was called out, the participants had to find the number on their card, which was ten more than the number called out. If the concept of the game was too difficult for participants in Group B or C, it was modified. For example, when playing *10 more bingo*, Group C had difficulty and the game was changed to *1 more bingo*. Prizes were occasionally given to the winners but mostly the participants enjoyed playing the game without requiring extrinsic rewards.

In each classroom session of the STP, anecdotal observational notes were recorded by the first author to determine the individual learning characteristics of the Group A participants.

Results

The results are presented first as a group analysis and second as selected individual case studies due to the small number of participants in each group.

Group Results

The results of pre and post test scores on the Booker Profiles of Mathematics (Booker 1995) are presented in Table 5. The table lists all of the Assessment Tasks (left hand side) participants completed both before and after the intervention of the STP and Games sessions. The number in the brackets indicates the maximum possible score for that section. Full details of each task can be found in Booker (1995). For example, the assessment task on *place value*, which is the focus of this study, explores participants' understanding of ones, tens, hundreds, etc. in different numbers. The eleven sections of the assessment tasks administered comprise the Booker Profiles of Numeration, one half of the Booker Profiles of Mathematics (Booker 1995). The other half of the assessment instrument is the Booker Profiles of Computation. This section of the test was not administered as this research concentrated on the numerical concept of *place value*, a fundamental skill to all other aspects of numeracy (Booker et al., 2010; van Kraayenoord & Elkins, 2009; Zevenbergen, Dole & Wright, 2004).

The comparison of pre and post test means (Table 5) show that some individuals in all Groups showed improvement in different sections of the test (improved scores are italicized and in larger font). The target group (Group A) showed improvements across all areas of the test except section two (language to materials) where the scores remained the same, and section 11 (rounding) which was not covered in the STP. Groups B and C, which only received the games sessions, did show some improvements in test scores, but these improvements were more varied and not as consistent as Group A.

The results for Group A showed an improvement across all areas of the assessment tasks that were covered in the STP except for section two (language to materials) where the average score was maintained but not improved. Improvement was shown in the *place value* section where the mean

Table 5. Mean Score Per participant On Assessment Tasks

	Group A		*Group B*		*Group C*	
Assessment Tasks	*Pre Test*	*Post Test*	*Pre Test*	*Post Test*	*Pre Test*	*Post Test*
1. Materials to Language (5)	2.60	3.20	3.30	5.00	0.75	2.00
2. Language to Materials (4)	1.60	1.60	3.60	3.60	0.25	0.75
3. Materials to Symbols (4)	1.60	3.20	3.60	3.00	0.25	0.75
4. Symbols to Materials (4)	2.00	2.60	4.00	4.00	0.75	1.00
5. Symbols to Language (4)	2.40	2.80	3.00	4.00	0.75	0.75
6. Language to Symbols (4)	2.00	2.80	3.30	3.30	1.25	1.25
7. Place Value (4)	0.40	2.00	2.60	3.60	0.25	0.00
8. Sequence (10)	3.60	4.00	7.30	7.60	1.50	2.75
9. Comparison (3)	0.40	0.60	0.60	0.60	0.25	0.25
10. Counting (4)	1.00	1.40	2.30	2.30	0.00	0.50
11. Rounding (1)	0.00	0.00	0.00	0.00	0.00	0.00

The number in brackets shows the total number of questions in each section.

improved from a score of 0.40/4.00 to 2.00/4.00. Other improvements include section one , materials to language from 2.60 to 3.20; section three, materials to symbols from 1.60 to 3.20 and section six language to symbols where students average scores improved from 2.00 to 2.80.

The *place value* scores also improved for Group B from 2.60/4.00 to 3.60/4.00. This group also showed improvements in three other areas. In section one (materials to language) there was improvement from 3.30 to 5.00, in section five (symbols to language) from 3.00 to 4.00 and in section eight (sequencing) from 7.30 to 7.60. Although it appears that Group B scored better in each section than the target group (Group A), it needs to be remembered that Group B began this project with higher scores across the board (see Table 4 and Table 2) and participants already had the beginning of an understanding of *place value*.

Comparing the improved scores of Group B with those of Group C, it is evident that Group C scores were not as high as Group B; however, they still showed some improvements across more areas than Group B. Group C improved in six sections of the test. Section one (materials to language), average sores improved from 0.75 to 2.00, in section two and three (language to materials and materials to symbols), from 0.25 to 0.75, section four (symbols to materials) from 0.75 to 1.00, section eight (sequencing) from 1.50 to 2.75 and section 10 (counting) from 0.00 to 0.50. Group C was the only group that did not show any improvements in *place value*.

Individual Case Study Profiles

Table 6 showed the individual scores of Group A participants. Sections where the individuals have improved have been italicized in larger numbers. To highlight the results, three individual case study profiles have been included. The three profiles have been chosen to highlight some of the particular achievements of the students in the STP.

Tom

The reason Tom was chosen to be profiled was because he was confident and correct in class but did not perform as well on the assessment for the study as would be expected from his achievement in class.

Background Information and Classroom Observations

Tom was 19 years, one month old and his receptive language was an age equivalency of 7 years, 3 months while his expressive language was an age equivalency of 6 years. Tom always worked eagerly in class completing classroom activities keenly and successfully. He showed a good understanding of what he was doing and would frequently complete exercises quickly and correctly. However, when it came to assessment tasks on the post test, which he had previously completed successfully in class, he was unable to recall his newly learnt skills.

Skills Achieved

As can be seen in Table 6, Tom did show some improvement in *sequencing* (section eight), where he scored five in the pre test and six in the post test. There was also improvement in section six, *language to symbols*, where Tom scored three in the pre test and four (100%) in the post test. In section seven (*place value*) Tom scored two on the pre test and three on the post test. In some of the 29 questions relating to *place value* and the ability to recognize and manipulate numbers on the post test (the first seven sections of the test), Tom showed an awareness of the concept even though the answer was incorrect e.g., when shown the number 47 constructed from the *base ten materials*, Tom said "four tens and seven ones…makes eleven," and when making 87 from the *base ten materials*, he made the number correctly and then said that it was 15 (the sum of eight and seven).

Edward

Edward was chosen to profile as he showed the most improvement of all of the participants in Group A.

Background Information and Classroom Observations

Edward was aged 20 years and his receptive language was an age equivalency of 8 years, 1 month while his expressive language was an age equivalency of 5 years, 11 months. Edward

Table 6. Group A Pre Test and Post Test scores

Name	*Materials to language (5)*[2]	*Language to materials (4)*	*Materials to Symbols (4)*	*Symbols to Materials (4)*	*Symbols to Language (4)*	*Language to Symbols (4)*	*Place Value (4)*	*Sequence (10)*	*Comparison (3)*	*Counting (4)*	*Rounding (1)*
David (pre)	3	2	1	2	1	2	0	3	1	1	0
(post)	2	1	4	2	1	2	0	2	1	1	0
Edward (pre)	3	1	1	2	2	1	0	3	0	2	0
(post)	3	1	4	2	3	4	4	4	1	1	0
Julie (pre)	3	2	1	2	2	2	0	1	0	2	0
(post)	5	2	4	4	2	3	0	3	0	1	0
Kylie (pre)	2	1	3	1	4	2	0	6	1	0	0
(post)	3	4	3	2	4	2	3	6	0	2	0
Tom (pre)	3	2	2	3	4	3	2	5	1	2	0
(post)	3	1	1	3	4	4	3	6	1	2	0

The number in brackets shows the total number of questions in each section.

always worked quietly and was very keen to please. He always tried to complete tasks, even new ones. He would frequently repeat mistakes and would write an incorrect answer rather than leave it blank if he didn't understand but did not get upset about having his work corrected. He was very pleased with himself when he learnt new skills.

Skills Achieved

Table 6 revealed that Edward showed improvement in areas involving *place value*. In section three (materials to symbols) Edward's score improved from one on the pre test to four (100%) on the post test. Sections six and seven also showed improvement with his score improving from one to four (100%) on section six and from zero to three (maximum score was four) on section seven. He also showed some improvement in sections five (symbols to language) and eight (sequence) where his score improved from two out of four to three and from three out of ten to four, respectively. There was a slight improvement in section nine (comparison) where Edward scored one correct response in the post test after he scored zero on the pre test. In section 10 (*counting*, which includes counting backwards), Edward's score improved from zero on the pre test to one out of five on the post test. In the 29 questions involving *place value* concepts (the first seven sections of the assessments), Edward achieved nine correct responses on the pre test and 20 correct responses on the post test. His comparison skills in recognizing greatest and least numbers, section nine of the assessment, also changed slightly on the post-test. Edward achieved one out of three correct on the post-test where he had not achieved any correct responses in the pre test.

Kylie

Kylie showed good improvements in some areas tested and was a very keen and interested student.

Background Information and Classroom Observations

Kylie was aged 20 years, 9 months and her receptive language age equivalency was 5 years, 8 months while her expressive language age equivalency was 5 years, 11 months. Typically, Kylie was pleased to participate in class activities particularly if she understood the work. If the work was difficult, she would often work very slowly and wait for the answers to be put on the board, or try and copy from other students. She was happy to ask for assistance most times and would work very hard once she understood the concept and was a keen games participant who was not really interested in prizes.

Skills Achieved

As can be seen in Table 6, Kylie improved in the *place value* skills of manipulating the *base ten materials* to read and construct numbers (sections one to four), during the nine-week implementation of the STP. Her scores improved from five out of nineteen on the pre test to twelve correct on the post test. She also applied her knowledge of *place value* to develop an understanding of the number of ones and tens in a number (section seven). Kylie achieved three out of four correct responses on the post test where she had failed to score any correct responses in the pre test. There was also improvement in section 10, *counting,* where Kylie's score improved from zero out of five to two out of five. During the pre test, Kylie answered 12 out of 29 questions involving the concept of *place value* correctly (sections one to seven). One of these was a picture of 37 using three bundles of ten paddle pop sticks and seven individual sticks. She achieved the correct answer by counting each stick separately not by counting the three bundles of tens as tens. During the post-test, Kylie answered 20 of the 29 questions correctly (including determining the number 37 by counting the tens and ones). She had much greater success when she manipulated the *base ten materials* rather than reading materials already constructed for her. Prior to the implementation of the STP, Kylie showed no signs of any knowledge of *place value* but after the program, she showed an awareness of ones and tens.

Discussion

The results demonstrate that these individuals with Down syndrome can learn the numeracy skill of place value with a program based on specific teaching, repeated practice, the use of concrete materials and games. This has been demonstrated through the improvement in performance

across almost all areas of the assessment tasks of students in Group A. Although Groups B and C also showed improvements, they were less consistent and less widespread than Group A. A discussion of the results follows.

The concept of p*lace value* was the main focus of the STP and the increase in results for Group A participants support the value of the STP and demonstrate that individuals with Down syndrome, are able to learn basic numeracy skills if they are taught appropriately. Neither Group B nor C showed as comprehensive a pattern of improvement as Group A which received both the STP and the games sessions.

The lack of improvement of Group A participants in section two of the test (language to materials) could be explained due to the short teaching period of the STP. To be able to manipulate the materials following a verbal prompt is a more abstract skill and hence more difficult than to start with the materials that you can then manipulate. Further instruction here was required.

Group B did show some improvements in some areas of the assessment; however, Group B started at a higher level of understanding than Groups A or C and already had a basic understanding of *place value.* The participation of Group B in the games sessions could have triggered links with previous knowledge in each area. Previous research has shown that linking new mathematical concepts with known concepts allows for a deeper understanding of new knowledge (Booker et al., 2010; Van de Walle, 2007). As these participants had completed schooling, participation in the games sessions would have assisted this group in remembering knowledge that they may have forgotten when they completed the pre-test and the games could also have linked with their prior knowledge and developed their understanding further. If Group B had participated in the STP as well as the games sessions, a greater improvement in results would have been expected.

Group C had lower scores across the board on the pre test and did not demonstrate an understanding in many areas of fundamental numeracy skill. For example, they did not display knowledge of a stable counting string and had difficulty manipulating materials and symbols to represent numbers. Hence, Group C had limited existing knowledge from which to develop further skills. The games developed for the STP frequently had to be adjusted for the level of learning required by this group. For example, when playing 10 more or less bingo, the game was adjusted for Group C to be 1 more bingo. Hence although some improvements were shown by participants in Group C which can be attributed to the games sessions they participated in, improvements were not expected to be as great as for the other two Groups. A targeted intervention program for this group of students could have shown a greater improvement in numeracy skills across the areas tested.

Group C was the only group that did not show improvements in *place value* from the pre test to the post test (the average score decreased from 0.25 to 0). This group were not specifically taught the skill of *place value*, only receiving the games session. Participants did not have the known concepts to link new mathematical concepts and develop a deeper understanding of new knowledge (Booker et al., 2010, Van de Walle, 2007). Hence, games alone could not be relied upon to teach new concepts. Games can enhance students learning but individuals with Down syndrome benefit from explicit teaching of numeracy concepts.

The results demonstrated that the games sessions did assist the participants in the development of some numeracy skills but that this improvement in understanding was not as great as for those students who had received a targeted, direct teaching program to develop those skills. Games can enhance numeracy development, but specific teaching of concepts is still required.

Conclusion

The data question the perceptions that numeracy education for individuals with Down syndrome should be confined to functional skills and concurs with findings of Bird and Buckley (1994) and Bochner, Outhred and Pieterse (2001) that numeracy achievements can be achieved with appropriate teaching.

As the results have demonstrated, improvement was shown by participants in all three groups but particularly participants in the target Group A, who received the STP and the games sessions. Although the improvements

were sometimes variable, the results show the importance of individualized targeted instruction. Furthermore, the results display the benefits of direct instruction with repeated practice and the use of concrete materials in conjunction with targeted and relevant games in the teaching of basic numerical skills.

There were two limitations in this study. First, the instruction provided through the STP was for a limited time, and second, there were a small number of participants in this study. Both of these issues could be addressed by further replication with greater sample sizes. Even though there were limitations, this study has demonstrated that with specifically directed teaching strategies, individuals with Down syndrome are able to show improvements in numeracy skill (*place value*) acquisition, an awareness of *place value*, an improvement in the individual's ability to complete tasks based on *place value* and increased ability to manipulate numbers and materials to solve problems.

This article presented the results of the STP that used teaching strategies considered to be effective in improving the numeracy abilities of individuals with Down syndrome. From the presented individual case studies, the additional information gathered from personal background data and classroom observation complemented the assessment results and illustrated the progress of the individual participants in Group A. These data have shown that even with such a short program of instruction, the strategies of explicit teaching, repeated practice and the use of concrete materials and games were effective in improving the numeracy skills of the participants in the target skill of "place value." As Shepperdson (1994) stated, "… if they are taught, individuals can learn." (p. 101).

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Key Messages From This Article

People with Down syndrome: You should never allow people to tell that you are not capable of learning because with the right help you can achieve many things.

Professionals: Explicit teaching strategies combined with the use of games can enhance the learning of place value concepts.

To help young people with Down syndrome learn place value concepts, teachers must:

- Determine their current level of understanding
- Target instruction to individual needs
- Directly teach concepts and strategies

Policymakers: Policy to ensure that young people with Down syndrome continue to receive access to quality academic education throughout school and beyond is necessary to promote the idea of lifelong learning.

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