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Problem Solving Abilities in Mathematics of Pupils with Spina Bifida and Hydrocephalus

This study researched the problem-solving abilities in mathematics of four pupils with spina bifida, hydrocephalus and a general learning disability. Qualitative methods of research were employed. The data was used to design an action research intervention with one pupil.

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INTRODUCTION

In 2002, the author carried out research into the maths problem-solving abilities of four teenage pupils with spina bifida, hydrocephalus and a general learning disability. The four pupils attended a special school in Dublin which caters for pupils with a physical disability. Initially a sample from across the school was considered. However this was not feasible and the four pupils were selected because the researcher had access to them on a daily basis. Qualitative methods of research were used as it was thought that this method would give a greater insight into the mathematical thinking of pupils with these conditions. The intervention was based on these findings. It could only be carried out with one pupil due to time constraints. It was designed as a piece of action research. A post-instruction test was also administered to this pupil.

SPINA BIFIDA AND HYDROCEPHALUS

Spina bifida is one of a number of congenital conditions known as neural tube defects (Anderson & Spain, 1977; Dunning, 1992). During pregnancy, the arches of one or more of the spinal vertebrae fail to fuse together. Through this gap either the spinal cord itself or its surrounding membranes, the meninges, protrude.

It is commonly accepted that spina bifida has two forms, spina bifida occulta and spina bifida cystica. It is the second type which has the more severe consequences. This article concerns itself with spina bifida cystica. Spina bifida cystica is again subdivided into two types, meningocele and myelomeningocele. Spina bifida meningocele is the less serious and the less common type. However in spina bifida myelomeningocele, the spinal cord not only protrudes into the sac but is itself abnormal resulting in permanent and irreversible neurological damage.

Approximately four out of five babies born with the myelomeningocele type of spina bifida also have hydrocephalus (Bayston, 1995a). In this condition too much cerebro-spinal fluid collects in the brain causing a build-up of pressure. Nowadays a valve can be inserted to drain off this fluid. For a child born with spina bifida myelomeningocele, the level of the disability depends on where the lesion occurs and its severity and extent. There can be paralysis or loss of sensation and incontinence. Children with hydrocephalus have ocular complications, usually squints, and the motor control of their limbs may be affected (Bayston, 1995a; Holgate & Batchelor, 1999). There may be long periods of hospitalisation and absences from school.

INTELLECTUAL PERFORMANCE ASSOCIATED WITH THESE CONDITIONS

When reviewing research one must be aware that the population of children with spina bifida cystica is not static. Tew (1987) writes how changing medical practices have affected *levels* of disability, both mental and physical. However, researchers in general agree on two points. The first is that this group of children does not show a normal distribution of intelligence and that their scores are skewed towards the lower end of the IQ range (Anderson & Spain, 1977; Carr, Pearson & Halliwell, 1983; Gallagher, 1985). The second point on which there is general but not universal agreement is the effect of hydrocephalus on IQ level and on school performance. Anderson and Spain (1977), Tew (1987), Carr et al (1983), Bayston (1995a) agree that shunt-treated hydrocephalus impairs intellectual performance. However Gallagher (1985), in her review of the literature on the subject, found conflicting views. The lack of agreement may simply reflect the difficulty in deciding who has got hydrocephalus (Gallagher, 1985). The presence of a shunt is usually taken to indicate the presence of hydrocephalus but as has already been described, hydrocephalus sometimes spontaneously arrests and no shunt is inserted. Yet it is possible that some damage may have been done to the child's brain at a very early stage. Lonton (1979), through using CAT scans, demonstrated the link between the damage caused by hydrocephalus and poor performance on psychometric tests.

Finally, some researchers (Anderson & Spain, 1977; Carr et al., 1983) have noted a discrepancy between verbal and performance scores of children with spina bifida on intelligence tests. However other researchers reviewed by Gallagher (1985) did not discover any significant differences.

SCHOOL ATTAINMENT IN THIS POPULATION

Research suggests that children with spina bifida perform particularly poorly in maths (Anderson & Spain, 1977; Carr et al., 1983; Gallagher, 1985). Not all agree that children with accompanying hydrocephalus have even greater problems. Anderson and Spain (1977) state, "taken together, the findings from different studies suggest that approximately three in four children with spina bifida and hydrocephalus have considerable difficulty with number work" (p. 209). Gallagher (1985) carried out research in a school for children with physical disability and also examined data on six hundred children with spina bifida. She concluded that it is the neurological damage present in children with hydrocephalus, which has the most direct effect on the development of mathematical concepts although this would also be influenced by the degree of physical disability and related environmental factors.

WORD PROBLEM SOLVING AS AN AREA OF DIFFICULTY

Word problem-solving became the focus of research. A review of the literature related to maths at the primary level established this as an area of difficulty for many pupils especially those younger and less able (Goodstein, Cawley, Gordon & Helfgott, 1971; Goodstein, 1973; Hickson-Bilsky & Judd, 1986; Carpenter, Ansell, Franke, Fennema & Weisbeck, 1993; Geary, 1994; Verschaffel & De Corte, 1997; Christou & Phillipou, 1998; Carpenter, Fennema, Franke, Levi & Empson, 1999). Pupils' ability to solve these problems is influenced by a variety of factors. These factors relate both to the characteristics of the problems and to those of the problem-solver. Researchers (Riley, Greeno & Heller, 1983; Carpenter et al., 1999) have classified one-step addition and subtraction word problems. There is a consensus of opinion, according to Verschaffel and De Corte (1997), about the relative difficulty of these types of word problems.

Problems are solved by means of strategies. The strategies used to solve words problems have been analysed (Siegler, 1987; Carpenter et al., 1993; Ostad, 1997; Carpenter et al., 1999). These researchers define three types of strategy. The first is based on direct modelling with fingers or physical objects. The second strategy is based on the use of counting sequences but where objects are sometimes used to "keep track" of the numbers. The third strategy is based on recalled number facts. Studies have shown a progression over time from counting strategies, through verbal counting and finally to fact retrieval (Ostad, 1997; Ostad, 1998; Carpenter et al., 1999). The most important point is that the more able/experienced pupil makes use of a variety of strategies whereas the less able/experienced pupil has less choice and tends to rely on the first or second strategy (Ostad, 1997; Ostad 1998).

Distractibility and Visual Perception Problems

There are some characteristics associated with poor performance on maths word problem solving which relate to pupils with spina bifida and hydrocephalus. Poor performance on maths word problem solving has been associated with general learning disability (Goodstein et al., 1971; Goodstein, 1973; Hickson-Bilsky & Judd, 1986). Pupils with spina bifida and hydrocephalus tend to have lower than average intelligence levels (Anderson & Spain, 1977). Distractibility is associated with the condition of hydrocephalus (Bayston, 1985b) and may also affect maths performance (Eisert & Shelburne, 1982; Gallagher, 1985). This group also tend to have visual–perception problems. Deficiencies in this area have been associated with certain sub-groups of pupils with specific maths learning disabilities (Rourke & Conway, 1997; Batchelor, Gray, & Dean, 1990; Booth & Thomas, 2000).

RESEARCH DESIGN

The research design was modelled on that of Erez & Peled's (2001) study of fifteen teenage pupils with general learning disabilities (but not with physical disabilities). The study investigated the cognitive schemes used by adolescents with mild and moderate general learning disabilities in the process of solving additive word problems. This study was chosen as a comparison study because there were similarities in age range and levels of learning disability. Also, the subject of the study, maths word problem-solving, had already been pinpointed as a source of difficulty in the research literature. Finally the study was well designed and researched.

THE SAMPLE

The pupils were aged fourteen and fifteen years and all had the diagnosis of spina bifida and hydrocephalus. Two of the pupils had mild general learning disabilities, one had a moderate general learning disability and one pupil was noted to be in the borderline range of general learning disability. Three of the pupils showed a difference between their Verbal and Performance I.Q. levels.

RESEARCH METHOD

Research took place over a two-month period which included the Easter holidays. During the initial assessment the pupils were observed as they worked on the tests. The pupils were audiotaped as they worked on the next three stages of the project.
Data collection consisted of four stages:

(i) **Four pupils completed Maths Mastery Check-up.**
(ii) **Four pupils completed the Contextual Word Problem Test.**
(iii) **Four pupils completed the Noncontextual Word Problem Test.**
(iv) **One pupil participated in an intervention which comprised seven instructional sessions and a test.**

The purpose of the initial assessment was to provide a context for research. "Maths Mastery" (Greaney & Close, 1985) is a popular textbook series and "Check-up" books are available at each level. Pupils worked on the criterion-referenced tests over a period of days and were given help with reading when necessary. These results also provided information for the next stage of the research. It established that one step addition and subtraction problems using smaller numbers (totalling no more than 12) were appropriate for this group. The word problems included samples of the different types of addition/subtraction problems listed by researchers (Riley et al., 1983; Carpenter et al., 1999). The problems were presented in two formats i.e. contextual and noncontextual (as were those in Erez and Peled's study). An example of a contextual word problem is the following: " Mary had 6 sweets. She gave some to Barry. Now she has 3 left. How many did she give to Barry?" The same problem can be presented in noncontextual format as follows: "Make a set of 6. Now make it into a set of 3. What did you do?" Erez and Peled

(2001) believe, as does the researcher, that presenting the problems in these two formats reveals even more about the pupils' mathematical thinking. Finally an intervention was designed based on the data collected at the second and third stage.

FINDINGS

The pupils with spina bifida were working below their chronological age as measured on the Maths Mastery Check-up (Greaney & Close, 1985). Overall performances of the pupils, as measured by the problem-solving tests and the initial assessment was, to a great extent, in keeping with their level of learning disability. Within the group, "A"- the pupil with the greatest level of learning disability - was working at the lowest level (Check-up 1). "B" – the pupil with the least level of learning disability - was working at the highest level (Check-up 3). However "X" and "Y", who have the same level of mild general learning disability, were working on Check-up 2 and Check-up 3 respectively. On the subsequent word problem-solving test the differences between them did not seem as great.

The findings from the non-contextual word problems indicated that pupils with a general learning disability have difficulties similar to their younger, non-disabled peers. This applied whether they had spina bifida, as in this study, or a learning disability only (Erez & Peled, 2001). The findings from the contextual word problems were inconclusive. There was some agreement about which problems were the easiest to solve but not about which were the most difficult.

Counting Strategies

Studies of pupils without specific learning disabilities have shown a progression over time from counting objects, through verbal counting strategies to number fact retrieval (Ostad, 1997; Ostad, 1998). This researcher has shown that pupils with a maths learning disability rely on the first two strategies almost exclusively. These findings were not entirely borne out by research with the pupils with spina bifida. "A", who performed at the lowest level of this group, could recall number facts but seemed quite unable to model a problem. "Y", who had less conceptual knowledge than "X", showed excellent recall of number facts. "X", on the other hand, used a strategy of counting on her fingers or on the hundred square. "B", who was working at the highest level in this group, used a mixture of number facts and derived number facts. One can speculate that this may be associated with individual patterns of storage and retrieval of facts, which may be related to brain damage. Erez & Peled (2001) did not analyse the strategies used by their pupils.
The pupils with spina bifida exhibited evidence of metacognitive skills, as did the pupils in the Erez and Peled (2001) study. They showed an awareness of and insight into their own actions. For example, they deliberately chose one strategy as being more appropriate or corrected themselves or consciously took shortcuts.

There is one finding associated with one of the pupils in this study which is not referred to in the research by Erez and Peled (2001). This is the high level of distractibility found in one pupil and which had a major influence on his performance. Distractibility can be a consequence of neurological damage (Bayston, 1985b; Gallagher, 1985) and has been related to achievement in maths by some writers (Eisert & Shelburne,1982; Tew, 1983; Haylock, 1991).

THE INTERVENTION

The intervention took place over a period of seven sessions, which had to be spread over a period of two weeks. “Y”, the pupil who had shown evidence of distractibility, was chosen as the subject. He was given instruction in modeling those types of problems with which he had difficulty. He was also given instruction in the metacognitive skill of self-checking. He was taught to direct his actions by saying the following to himself as he worked on a problem:

Read the problem. Say it to yourself.
Read it again.
Check you have the numbers right.
Check you have the question right.

Montague (1992; 1997) and Xin and Jitendra (1999) have shown the usefulness of instruction in metacognitive skills with pupils with both specific maths learning disabilities and mild general learning disabilities. The pupil demonstrated use of both cognitive and metacognitive skills as well as increased conceptual knowledge during the instructional sessions. However these skills were only partially maintained one week later. This was not surprising given the short-term nature of the intervention. Xin and Jitendra (1999) have shown that longer term interventions are necessary for pupils with learning disabilities.

CONCLUSION

This study has shown that some pupils with spina bifida and hydrocephalus experience difficulties with maths problem solving which are similar to younger pupils and those with learning disabilities. They show a pattern of development which is delayed rather than different. The study suggests that some pupils with this condition experience difficulties which may relate to their physical disability of spina bifida with hydrocephalus . Their pattern of strategy use may indicate difficulties as well as strengths associated with verbal recall. Distractibility can be a feature of this condition and it also has consequences for learning. Metacognitive instruction may also be a useful tool in addressing some of these pupils’ problems. Further research in this area would be fruitful.

REFERENCES

Anderson, E.M., & Spain, B. (1977). *The child with spina bifida.* London: Methuen and Co. Ltd.

Batchelor, E.S., Gray, J.W., & Dean, R.S. (1990). Empirical testing of a cognitive model to account for neuropsychological functioning underlying arithmetic problem solving. *Journal of Learning Disability, 23*(1), 38-41.

Bayston, R. (1995a). Hydrocephalus: What it is and what causes it. *Hydrocephalus Network News, Summer, i-iii.*

Bayston, R. (1995b). The effects of hydrocephalus. *Hydrocephalus Network News, Autumn, i-iii.*

Booth, R.L,. & Thomas, M.O. (2000). Visualisation in maths learning: Arithmetic problem-solving and student difficulties. *Journal of Maths Behaviour, 18*(2), 169-190.

Carpenter, T.P., Ansell, A., Franke, M.L., Fennema, E., & Weisbeck, L. (1993). Models of problem solving: A study of kindergarten children's problem-solving processes. *Journal for Research in Mathematics Education, 24*(5), 428-441.

Carpenter, T.P., Fennema, E., Franke, M.L., Levi, L., & Empson, S.B. (1999*). Children's mathematics: cognitively guided instruction*. Portsmouth, N.H.: Heinemann.

Carr, J., Pearson, A., & Halliwell, M. (1983*). The G.L.C. spina bifida survey: Follow-up at 11 and 12 years*. London: The Greater London Council.

Christou, C., & Phillipou, G. (1998). The developmental nature of the ability to solve one-step word problems. *Journal for Research in Mathematics Education, 29*(4), 436-442.

Dunning, D. (1992*). Children with spina bifida and/or hydrocephalus at school.* London: A.S.B.A.H.

Eisert, D.C., & Shelburne, K. (1982). Children with spina bifida: Why do they fail in school? *Paper presented at the annual convention of the A.P.A.*, 23-27 August, Washington, D.C.

Erez, G., & Peled, I. (2001). Cognition and metacognition: Evidence of higher order thinking in problem-solving of adolescents with mental retardation. *Education and Training in Mental Retardation and Developmental Disabilities, 36*(1), 89-93.

Gallagher, M. (1985). *Factors affecting the development of mathematical concepts in children with spina bifida and hydrocephalus.* Ph.D.Thesis, Open University, Milton Keynes.

Geary, D.C. (1994*). Children's mathematical development: Research and practical applications.* Washington, D.C.: American Psychological Association.

Goodstein, H.A., Cawley, J.A., Gordon, S., & Helfgott, J. (1971). Verbal problem solving among educable mentally retarded children. *American Journal of Mental Deficiency. 76*(2), 238-241.

Goodstein, H.A. (1973). The performance of educable mentally retarded children on subtraction word problems. *Education and Training of the Mentally Retarded, 8*(4), 197-201.

Greaney, V., & Close, S. (1985). *Maths Mastery check-up and teacher's manual.* Dublin: The Educational Company.

Haylock, D. (1991). *Teaching maths to low attainers: 8-12*. London: Paul Chapman Publishing Ltd.

Hickson-Bilsky, L., & Judd, T. (1986). Sources of difficulty in the solution of verbal arithmetic problems by mentally retarded and nonretarded individuals. *American Journal of Mental Deficiency, 90*(4), 395-402.

Holgate, L., & Batchelor, R. (1999). *Hydrocephalus and you.* Peterborough: Association for Spina Bifida and Hydrocephalus.

Lonton, A.P. (1979). The relationship between intellectual skills and the computer axial tomograms of children with spina bifida and hydrocephalus. *Zeitschrift fur Kinderchirurgie, 28*(4), 368-374.

Montague, M. (1992). The effects of cognitive and metacognitive strategy instruction on the mathematical problem solving of middle school students with learning disabilities. *Journal of Learning Disabilities, 25*(4), 230-243.

Montague, M. (1997). Cognitive strategy instruction in mathematics for students with learning disabilities. *Journal of Learning Disabilities, 30*(2), 130-141.

Ostad, S.A. (1997). Developmental differences in addition strategies: A comparison of mathematically disabled and mathematically normal children. *British Journal of Educational Psychology, 67*, 345-357.

Ostad, S.A. (1998). Developmental difference in solving simple arithmetic word problems and simple arithmetic number-fact problems: A comparison of mathematically normal and mathematically disabled children. *Mathematical Cognition, 4*(1), 1-19.

Riley, M., Greeno, J., & Heller, J. (1983). The development of children's problem-solving ability in arithmetic. In H.P.Ginsburg (Ed.), *The development of mathematical thinking*. Developmental Psychology Series. New York: Academic Press.

Rourke, B.D., & Conway, J. (1997). Disabilities of arithmetical and mathematical reasoning: Perspectives from neurology and neuropsychology. *Journal of Learning Disabilities, 30*(1), 34-46.

Siegler, R.S. (1987). Strategy choices in subtraction. In J.A. Sloboda, & D. Rogers (Eds.), *Cognitive processes in mathematics.* Keele Cognition Seminars. Oxford: Clarendon Press.

Tew, B. (1983). *An Investigation into the psychological and educational consequences of spina bifida cystica and its complications.* Ph. D. Thesis, Open University, Milton Keynes.

Tew, B. (1987). Changes in medical Practice towards the child with spina bifida: implications for schools. *Disability, Handicap and Society, 2*(1) pp.85-99.

Verschaffel, L., & De Corte, E. (1997). Word problems: A vehicle for promoting authentic maths understanding and problem-solving in the primary school? In T. Nunes & P. Bryant (Eds.), *Learning and teaching maths: An international perspective.* U.K.: Psychology Press Ltd.

Xin, Y.P., & Jitendra, A.K. (1999). The effects of instruction in solving mathematical word problems for students with learning problems: A meta analysis. *The Journal of Special Education, 32*(4), 207-225.