

FINDINGS OF STUDIES ON DYSCALCULIA – A SYNTHESIS

By

B. WILLIAM DHARMA RAJA *

S. PRAVEEN KUMAR **

* Assistant Professor, Department of Education, Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu.

** Assistant Professor, Bethlahem College of Education, Karungal, Kanyakumari District, Tamil Nadu.

ABSTRACT

Children with learning disabilities face problems in acquiring the basic skills needed for learning. Dyscalculia is one among those learning disorders which affects the ability to acquire arithmetic skills that are needed to perform mathematical calculations. However this is a learning difficulty which is often not recognized.

The objectives of this paper are to review studies and related literature on different types of dyscalculia; dyscalculics at various levels; relating dyscalculia to other learning disabilities; methods for overcoming dyscalculia; and comparison of dyscalculics and normal children. The dissertation abstracts international (1990-2010), the educational and psychological journals both at national and international levels, websites and related books have been reviewed for fulfilling the objectives of this paper. Among the studies reviewed, ten are taken from dissertation abstracts international, eleven from journals and six are from websites. The related literature is also collected from five books and from an Indian newspaper. Review of studies reveals the fact that less research has been done in the area of mathematical deficiencies. The need to conduct more researches on dyscalculia is essential in order to mitigate the problems of dyscalculics.

Keywords: Learning Disabilities, Dyscalculia, Dyscalculics.

INTRODUCTION

In most of the schools, one may come across some specific group of children who face problems in learning. These problems can be found in their acquisition of basic academic skills such as reading, writing or arithmetic. This condition in which a learner finds it difficult to acquire the basic skills needed for learning is called 'learning disability'.

Children with learning disabilities are low achievers and they are found to be unable to cope with the schoolwork. The difficulty in learning to read, write, or calculate is represented as discrepancy between the learner's achievements and his/her ability to learn. Unexpected underachievement has been attributed to intrinsic neurological factors which indicate that students with learning disabilities require specialized instruction to perform at expected levels (Kumar et al, 2009). These children are found to have different kinds of learning disabilities of varying degrees. The most common types of learning disabilities are dyslexia (disorder of reading),

dysgraphia (disorder of written work) and dyscalculia (disorder of performing arithmetic calculations). Dyscalculia or arithmetic disorder is a less widely known disability, similar and potentially related to other learning disabilities like dyslexia, dysgraphia, dysphasia and dyspraxia and is seldom identified.

What is Dyscalculia?

Many of the children with learning disabilities may be found to exhibit serious learning difficulties in mathematics primarily related to mathematical calculations and mathematical reasoning. The difficulties that children face in the learning process have begun to attract serious attention. It has become a real educational handicap and a widespread issue in today's society (Kumar & Raja, 2009).

Dyscalculia is the most widely used term for the learning problems and difficulties in mathematics faced by the children with learning disabilities (Mangal, 2007). It is a learning disorder which hinders the ability to acquire arithmetic skills that are needed to perform mathematical

calculations. It is a specific learning disability in which pupils face severe problems in the acquisition of mathematical skills.

There are a range of warning signs exhibited by dyscalculic learners in their mathematical difficulties. These include slowness in giving answers to mathematics questions in comparison with other learners, difficulties in mental calculations, using fingers to count simple totals, mistakes in interpreting word problems, difficulty to remember basic mathematics facts, losing track when counting or saying multiplication tables, difficulty in remembering the steps in a multistage process, difficulties with position and spatial organization (Hannell, 2005).

A child with a learning disability has problems in most types of subject matter while a child with a specific learning disability has a major problem with one type of subject material like arithmetic (Jaya & Geetha, 2004). So specific learning disabilities like dyscalculia call for focused instruction and guidance. In many ways, it is the mathematical equivalent of dyslexia which is a specific difficulty with literacy.

Dyscalculia – Types

Dyscalculia is observed in children in many types and subtypes. Dyscalculia which occurs during the later stages of life is known as acalculia. It is acquired due to injuries caused in the brain. However it is not acquired during the normal stage of learning. The term acalculia is generally used to describe an acquired disorder of calculating ability resulting from brain damage (Reynolds & Janzen, 1997).

Mathematical learning difficulties that share features with acquired dyscalculia but without evidence of cerebral trauma are called developmental dyscalculia (Munro, 2003). Underachievement due to developmental disability has a neurological foundation. The students lack particular cognitive or information processing strategies necessary for acquiring and using arithmetic knowledge. In cases of developmental dyscalculia, the mathematical abilities fail to develop within the normal limits of time and sequence (Reynolds & Janzen, 1997).

On the basis of the nature of difficulty, the developmental dyscalculia can be fabricated into seven different types. There are verbal, practogonistic, lexical, graphical, ideognostic, operational and sequential dimensions of dyscalculia.

Verbal dyscalculia

Verbal dyscalculia Refers to the difficulty with verbal use of mathematical concepts. Children with this type of dyscalculia may be able to make normal mathematical calculations. However they may not be able to verbally name the signs, symbols or to do counting of the numbers and different items.

Practogonistic dyscalculia

Practogonistic dyscalculia Refers to the difficulty in converting one's arithmetic knowledge to actions or procedures in relation to quantities.

Lexical dyscalculia

Lexical dyscalculia is the difficulty in reading mathematical symbols and numbers.

Graphical dyscalculia

Graphical dyscalculia is nothing but the difficulty in writing mathematical symbols.

Ideognostic dyscalculia

Ideognostic dyscalculia denotes the difficulty in comprehending mathematical ideas and relationships.

Operational dyscalculia

Operational dyscalculia refers to the difficulty in performing basic arithmetic operations. It is also associated with difficulty in applying rules of mathematics during mathematical operations. Children with this type of dyscalculia also have confusion in mathematical symbols.

Sequential dyscalculia

Sequential dyscalculia refers to difficulty to count numbers according to sequence. It is also associated with difficulty in calculating time, checking schedule, tracking direction and taking measurement.

Studies on Dyscalculia – Status Quo

Studies in the area of mathematical disabilities are far

fewer compared to those on the area of reading or writing disabilities. This is mainly due to a large focus on reading and writing and less attention is given to the quantitative aspects of thinking (Nakra, 1996). One study on dyscalculia was first conducted on children in 1974 by Ladislav Kosc in Bratislava. His findings showed that dyscalculia was a structural disorder of mathematical abilities. Later many studies were conducted on dyscalculia and various results were obtained regarding the symptoms of dyscalculia, the problems faced by children in learning arithmetic and also the overlapping of dyscalculia with other learning disabilities (<http://stgabss.net>).

Recent investigations in this field have shown that a person of normal intelligence can easily cope with this subject. Mathematical ability has nothing to do with general intelligence and it requires no talent at all (Geetha, 2008). Even then the performance in mathematics is generally poor and pupils find it to be a difficult subject. As a result these pupils can develop a phobia towards the subject. Although such children have problem with calculations, they may be good at other academic subjects. Dyscalculics may also have good reading, writing and speaking skills (<http://www.indiaparenting.com>).

Mathematics is a subject which requires various skills such as perceptual reasoning, verbal reasoning, counting and calculating. If the basic mathematical skills are not mastered, schoolchildren may find it difficult in moving on to more advanced mathematical applications. The poor quality of learning at elementary stages gives children a weak foundation and it directly affects their learning at the high school stage and even carries over further. Many children are found to be mathematically challenged rather than dullards. Learning achievement surveys taken by the National Council of Educational Research and Training (NCERT) recently show that mathematics teaching calls for more attention to help children acquire the basic skills of mathematics (The New Indian Express, 2008). So the task of teaching mathematics to students has become a more challenging one.

Findings on Different Types of Dyscalculia

Although there are limited studies on developmental dyscalculia, acalculia is yet to be studied. In the study regarding developmental dyscalculia and basic numerical capacities among eight to nine year-old students, it is learned that dyscalculia is the result of specific abilities in basic numerical processing rather than the consequences of deficits in other cognitive abilities (Landerl. et al., 2004). Orly and Avishai (2006) on conducting their study on developmental dyscalculia have found that dyscalculic population has difficulty in automatically associating numerals with magnitudes but these people have no problem in associating letters with phonemes. The need to study all types of dyscalculia is essential in order to know how they affect the mathematical abilities of learners.

Findings on Dyscalculics at Various Levels of Education

A learning disability like dyscalculia cuts across class, age and intelligence. Children with arithmetic difficulties are found in all age groups and early identification is very important (Nakra, 1996). Learning disabilities are found across all ages and in all socio-economic classes. They may affect individuals differently at different stages of life - early childhood, elementary school years, adolescence and adulthood. Students with learning disabilities may be identified at any age, but most of them are first noticed in early elementary school grades (Ysseldyke & Algozzine, 2006). The reviewed studies indicate that the dyscalculics are spread over both at school and college levels.

Studies on dyscalculics in primary schools

While analyzing the neuro-psychological processes and the arithmetic errors committed by the students studying in primary schools, it was found that the majority of dyscalculics experienced difficulty in reading and writing more than two digits, in sequential reproduction and seriation of numbers, and also in solving problems involving spatial and numerical relations (Ramaa, 1990). Robinson (2003) examined number facts performance in a sample consisting of 318 children with learning disabilities of the third grade in six public schools. They were divided into three groups namely students with

mathematics disabilities alone, students with concomitant mathematics and reading disabilities, and a contrast group. The study shows that on the one hand, children with both phonological processing and number sense weaknesses had greater difficulty in mastering the number facts. The students with mathematics difficulties alone were found to be able to use their phonological processing skills to compensate for observed weakness in number sense. If these problems are not detected at an early stage, they will prevail at the higher stages of learning. A study by Vukovic & Siegel (2010) which investigated the academic and cognitive characteristics of persistent Mathematics Difficulty (MD-p) from first to fourth grade indicated that the MD-p group was more likely than other groups to have deficits in calculation, practical problem solving, number facts, and reading and that in terms of cognitive characteristics, MD-p was specifically characterized by deficits in math concepts and phonological decoding, though there was some evidence for the involvement of working memory, processing speed, and numerical reasoning.

Studies on dyscalculics in secondary schools

An investigation into the learning difficulties of simple fractions of Indian children in secondary schools show that one third of all the mistakes in division of fractions were due to the student's negligence to invert the divisor before the process of multiplication; one fourth of all mistakes in the division of fractions were due to the student's lack of comprehension of the process involved (Maite & Mete, 2006). On assessing the children with learning disabilities at secondary school in the area of equation-sums in algebra conducted by Bhattacharya (1988) it was found that students had more learning disabilities in application than in the knowledge of linear equations and also it was found that the simplified method was more effective than the method of transposition in solving linear equation sums. On studying the effectiveness of certain instructional strategies to overcome learning disabilities in arithmetic among secondary level schoolchildren, it was found that there was significant difference in the post-test performance of learners than in the pre-test performance of learners with the use of instructional strategies such as

CATL, MSTL, SGTL, CT retention test and achievement of CAD (Kumar, 2006).

Studies on dyscalculics in colleges

Studies done on dyscalculics at the collegiate level are fewer in number than those done at the primary and secondary levels of school education. The study of Evans and Ellen (2003) showed that students with learning disabilities were satisfied with the accommodations they received in their university-related mathematics courses.

Toppel (1996) investigated the effects of a labeling plus diagramming strategy and a labeling only strategy on the mathematical word problem solving ability of learning disabled community college students. The results of the study showed that only six students of the labeling plus diagrammatic group did not improve in their ability to solve mathematical relational word problems; however these learning disabled students improved in the relational word problems as compared to only two out of the seven learning disabled students in the labeling group.

Findings on Relationship of Dyscalculia with Other Learning Disabilities

Even though the cognitive sciences have not yet been able to establish a thorough understanding of the origins of dyscalculia, there have been several discoveries that have helped to develop some important correlations between dyscalculia and other learning and psychological disorders. Approximately 17 percent of dyscalculic children are also dyslexic and another 26 percent experience the effects of attention deficit hyperactivity disorder (Michaelson, 2007). Many studies have shown that a considerable number of dyscalculic children suffer concurrently from additionally ascertained difficulties. Some studies at the same time disprove this claim of link between dyscalculia and other learning disabilities. The attempts taken for this paper throw light on the studies of dyscalculia linked with other learning disabilities namely dyslexia and attention deficit hyperactivity disorder.

Studies connecting dyscalculia and dyslexia

Dyscalculia is just as common as dyslexia and yet it is not

as widely recognized by teachers, parents, school authorities or by the government. Hence dyscalculic learners require special education in the same way as dyslexics. There is a considerable overlap between the two disorders dyslexia and dyscalculia. A few studies claim that dyscalculia is more common in children than dyslexia or word blindness. But unlike dyslexia, very little is known about its prevalence, causes or treatment (Diwan, 2008).

Studies suggest that somewhere between 20 and 60 percent of pupils have both dyslexia and dyscalculia. Deficits in language and memory may also create problems in the acquisition of mathematics and literacy skills (Hannell, 2005).

Children who have difficulty in literacy skills also have trouble with mathematics. Research studies show that rapid retrieval of abstract knowledge from long term memory is also likely to be shared by literacy and arithmetic learning. It has been estimated that 40 percent of dyslexic children can also have trouble with learning mathematics (Pollock & Waller, 1997).

Concerning the review of studies on relationship between dyscalculia and dyslexia, a study (Orly & Avishai, 2006) has revealed that dyscalculics have difficulty in automatically associating numerals with magnitudes but no problem in associating letters with phonemes, whereas dyslexics show the opposite pattern. In another study on naming speed in dyslexia and dyscalculia, it is found that the cognitive bases of dyslexia and dyscalculia are independent of each other (Willburger et al., 2008).

Studies connecting dyscalculia and ADHD

On assessing the familial relationship between dyscalculia and attention-deficit hyperactivity disorder (ADHD) by using structured diagnostic interviews and a cognitive test battery, it was found that ADHD and dyscalculia are independently transmitted in families and are etiologically distinct (Monuteaux et al, 2005). The necessity to study other learning disabilities connected with dyscalculia is essential in order to know how they hinder the mathematical abilities of students.

Findings on Strategies for Overcoming Dyscalculia

Dyscalculia is seen to be a specific learning disability and requires diagnosis as well as support apart from classroom teaching. Diagnosis may be done through observing and testing all the areas of academic skills. Teachers play a crucial role in diagnosing the learning difficulties of such students and parents are not an exception. It is obvious that there is a need for reliable and supportive strategies that help to overcome this learning disorder. There are supportive studies on various strategies to minimize and overcome dyscalculia.

Strategies using audio-visual technologies

Technology can greatly aid the process of mathematical exploration and clever use of such technology can help to engage students with learning disorders. Chen (2005) on evaluating the efficacy of mathematics interventions for children with learning disabilities discovered that behavioural, cognitive and technology-based intervention categories were highly effective for group design studies but moderately effective for single subject design studies and they could be effectively implemented for students with learning disabilities in mathematics.

It must be understood that there is a spectrum of technology use in mathematics education and calculators or computers are at one end of the spectrum. The use of pictures, blackboards etc. are at the other end and the use of graph paper, geo boards, abacus, geometry boxes etc. is crucial. Innovations in the design and use of such material must be encouraged so that their use makes school mathematics enjoyable and meaningful. The study which attempted to diagnose the problems in reasoning faced by the students in learning geometry and their prevention revealed that the experimental group taught by audio-visual materials and techniques achieved significantly more than the control group taught by the conventional method and that learning through the audio-visual materials caused more prolonged retention than through the conventional method (Dutta, 1990).

The use of technology like multimedia instructional

technology or computer-assisted instruction may facilitate the process of mathematical exploration in dyscalculic learners. By these specialized approaches to teaching, most dyscalculic learners can be helped to learn normally (Kumar & Raja, 2008). Nwaizu & Ifeanyi (1991) in their study found that students had higher retention level of multiplication facts mastered during computer-assisted instruction (CAI) than during teacher-assisted instruction.

The study (Calhoun, 2000) on the effects of computer-based test accommodations on mathematics performance for secondary students with learning disabilities reveals that providing a reader, either human or computer significantly increased mathematics performance of the respondents.

Multimedia approach to teaching is a strategy that comprises more than one instructional technique for teaching a particular unit. The use of various educational media may help to overcome the academic difficulties of children with learning disabilities. In a study (Vasanthi, 1991) done on the development of a multi-media instructional system for remedial measures in fractional numbers, it was found that the multimedia instructional system helped the students in improving their performance on the computational skills in fractional numbers.

Mohankumar and Rajaguru (2002) on evaluating the effect of using multimedia instructional strategy for children with learning disabilities found that multimedia instruction facilitated such students in learning algebra concepts rather than their counterparts in conventional teaching group. On exploring the effects of multimedia-based instructional technology on the problem-solving in Algebra skills of ninth through twelfth grade students with learning disabilities it is shown that multimedia computer technology could be a potential supplementary teaching aid that teachers use in addition to traditional classroom instruction (Lugo, 2005). The research done by Stultz (2008) which determined if computer-assisted instruction was as effective as other methods of instruction that do not use computers for teaching mathematics to students with a specific learning disability showed that a

statistically significant difference did not exist between the two methods of instruction and that individual student characteristics or other factors may interact with the method of instruction utilized when teaching students with specific learning disability.

Other innovative instructional strategies

Shih (2006) on studying the effects of number sense intervention on second-grade students with mathematics learning disabilities found that students who received repeated practice followed by number sense instruction had better initial performance on fact retrieval and could generalize what they learned to more novel tasks such as solving word problems. One study (Moomaw & Coup, 2008) on measuring number sense in young children reveals that mathematics-based curriculum measure that can be used to assess the ongoing development of quantitative reasoning in children is a valid and reliable measure of number sense.

It is very essential for school teachers to adopt innovative methods of teaching to meet the needs of dyscalculic learners. The study which centred upon the problem of development of teaching steps for handling children with arithmetic disorders through developing scientific steps in teaching addition and subtraction revealed that with training and following the teaching steps, the subjects with disabilities could perform in a better way and retain in the memory what they learned for a long period (Mishra, 1991). Flores (2004) on comparing the effects of two methods of teaching multiplication facts to middle school students with learning disabilities found that among the two instructional methods namely strategic instruction and constant time delay, strategic instruction was more effective than constant time delay with regard to skill maintenance and generalization.

Another study regarding methods for ascertaining and accommodating dyscalculic children in the classroom conducted by Michaelson (2007) suggests that certain practical methods and instructional designs can be implemented in the classroom to address the specific learning needs of dyscalculic learners which help them to learn mathematics in a meaningful and enjoyable way

through activities. The study done by Ota (2008) to determine the responsiveness of the elementary-aged students with and without specific learning disabilities to interventions for mathematics calculation revealed that empirically-derived interventions were effective in enhancing the calculation skills of students with and without specific learning disabilities and maintaining their skills during and after the intervention phase and that the students demonstrated high levels of satisfaction with the interventions and enhanced their self-efficacy across the study.

Findings on Comparison of Dyscalculics and Normal Children

The reviewed studies on comparing dyscalculics with normal children are only a few in number. On studying the factors of cognitive development in two groups of seventh-grade students evidencing dyscalculia, it was found that students affected by dyscalculia were different from their mathematically achieving counterparts on two factors of cognitive style namely field dependence and independence, and spatial visualization (Tishler, 1981). Another study (Owen, 2005) done on the comparison of mathematical problem-solving errors between third-grade students with learning disabilities and peers without disabilities indicated that students with learning disabilities made more errors in the translation of word problems than in computation.

On comparing students with mathematics learning disabilities and students with low mathematics achievement in solving word problems, it was shown that students with low mathematics achievement had more computational errors but fewer translation errors when compared to students with mathematics learning disabilities who had conceptual difficulties in the areas of analyzing, reasoning and abstract thinking (Hartmann & Ann, 2008). Mussolin et al (2010) while researching on Symbolic and nonsymbolic number comparison in children with and without dyscalculia found that DD children showed a greater numerical distance effect than control children, irrespective of the number format.

Implications

Dyscalculia is seen to be a developmental as well as an acquired learning disability and the effects of this disorder can be controlled with appropriate support, guidance and interventions at home and school. A learning disability like dyscalculia is highly prevalent among schoolchildren and has become a serious hindrance in today's educational scenario. Once parents and teachers notice that children have severe problems with arithmetic skills, they can seek help from qualified professionals. Following identification, parents and teachers can work together to establish strategies that may help these children to learn in an effective way.

Parents need to be aware of the various learning blocks that children face in their day-to-day life and how they hamper their progress. Awareness about mathematics learning difficulties can help the parents to give appropriate remedial measures to their children and create the kind of climate which is conducive to their learning. The parents have to accept the fact that their children can learn only at their pace of learning and it is no good pushing them beyond their ability to learn. With proper parental care, dyscalculics may be made to develop their arithmetic skills.

Awareness about difficulties that dyscalculics face can enable teachers to open their eyes more to the ways of helping them. Teachers have to become aware of the compensatory strategies that they can use to make these students complete the mathematical tasks and to learn mathematics successfully. As a teacher learns about the difficulties faced by each student in learning mathematics, he/she can adopt the right kind of instruction to cater to their specific needs. By choosing materials and activities suited to their level of learning and by stimulating their urge to bring out their best, teachers can help the pupils with arithmetic learning disabilities to turn their difficulties into special opportunities to be model achievers. It is essential for teachers to be acquainted with the new technologies, learn more about them, and also determine how they may be most appropriately used to facilitate learning.

A learning disability like dyscalculia need to be studied intensively to meet the special needs of dyscalculics who need special attention to learn mathematics effectively. Mathematically disabled individuals need special support apart from classroom teaching. They require special help to learn normally through specialized approaches to teaching. So it is becoming imperative for researchers to conduct surveys and experiments in this area to meet the special needs of dyscalculics who need special attention.

Recommendations to Researchers

Mathematical skills are indispensable for learning and more researches in this area are becoming increasingly needed. A specific learning disability like dyscalculia needs to be investigated to meet the needs of mathematically handicapped children. Children with these problems require diagnosis as well as support apart from classroom instruction. It is imperative for researchers to come forward to study arithmetic learning disorders and adopt certain ways and means to treat these disabled learners.

The problems of dyscalculics need to be studied from different angles. The need to study each and every type of dyscalculic problem is quite essential. Identification of different types of dyscalculics in different stages of education namely primary, secondary and tertiary level needs to be done. Studies need to be carried out on comparison of dyscalculics with learners affected by other disorders like dysgraphia, dysphasia or dyspraxia. More studies in this area will shed light on the differences between dyscalculics and normal children.

It is essential for researchers to carry out investigations on new technologies that may be most appropriately used to facilitate learning. Experimental studies, both culture fair and culture specific on innovative methods of instruction other than the computer technologies need to be done for the benefit of the arithmetic-disabled children. Researchers need to conduct more intensive studies on this area and suggest suitable measures to treat these academic sufferers.

Conclusion

Dyscalculia is a learning disability which requires special support apart from classroom teaching. The special support includes the roles of special educators, medical experts and therapists. Dyscalculics clearly require help to learn normally through early recognition and specialized approaches to teaching. Rehabilitation programmes have to be planned for these children according to their level and nature of dysfunction. Acquisition of arithmetic skills is indispensable for academic excellence of the learners and so the need of researches in this area is keenly felt.

The task of teaching a child with dyscalculia is indeed challenging and by becoming aware of the strategies that can mitigate the learning difficulties in mathematics, instructors can grow in confidence in accomplishing this complex task. Educational planners need to address the concerns of these intellectual sufferers and come to their rescue with the provision of sufficient funds for researchers to find out ways and means to minimize learning difficulties in mathematics and for the development of infrastructure for inclusive learning in as many schools as possible.

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ABOUT THE AUTHORS

Dr. B. William Dharma Raja, Assistant Professor in Education in Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, India, is a recipient of Excellence Award for research activities from Directorate of Teacher Education, Research and Training, Chennai (2006), Air India's BOLT (Broad Outlook Learner Teacher) Award (2004), Award for Innovation in Teacher Education by National Council for Educational Research and Training, New Delhi (2003) and British Council's First-time Speaker Award (2002). He has commendable service in Tamil Nadu Open University, Chennai, and District Institutes of Education and Training (DIETs) in Tamil Nadu. He has more than 100 contributions in the form of research papers/articles in Journals and papers presented in seminars/conferences from regional to international levels to his credit. Currently he is engaging himself in systematic researches in teacher education, in general and educational psychology and educational management, in particular fused with special education.



Dr. S. Praveen Kumar is currently working as an Assistant Professor in Bethlahem College of Education, Karungal, Tamil Nadu, India. His doctoral work is on Mathematics learning disabilities under the supervision of Dr. B. William Dharma Raja. He has presented fifteen papers at the National and the International level seminars. He has published a book and ten articles in reputed Journals.

