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Research in Mathematics Education

A TREND REPORT

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India has a long history of teaching and learning mathematics dating back to the Vedic Age (1500 to 200 BC). During the period AD 200 to 400, several works on astronomy and mathematics were composed, mainly based on indigenous knowledge. Most notable of this period is the contribution of Jaina mathematicians. The Jaina texts prescribed arithmetic as one of the most essential requirements for children's first education. During the period of AD 400 to 1200, a new branch known as *Ganita* came into existence with three separate components namely, arithmetic, algebra and geometry. But mathematics received prominence as a separate subject only in the 12th century, as referred to in the *Leelavati* of Bhaskaracharya. The situation with regard to mathematics education remained unchanged after AD 1200 though there had been epochmaking discoveries. In spite of political instability during the period up to the 18th century, the native system of education maintained its traditional structure up to the advent of British.

In post-independent India, great emphasis has been placed on mathematics teaching and learning. The Education Commission (1964–66) recommended mathematics as a compulsory subject for students at school level. The commission seemed to have been influenced by international opinion at that particular time and favoured 'new mathematics', which later pervaded secondary education. That was the era of sets, and the algebra of sets.

The science of 'mathematics education' is still in its infancy. In any curriculum, content and presentation of content are the two most important and inseparable components. The application of learning theories in content presentation is of very recent origin. Research evidence is inadequate to say anything definite about which method is going to be the most effective for presentation of a particular type of content. However, methodology also involves the arrangement of the content in a hierarchical manner. The entire process is composed of complex psychological principles. The commission points out that, 'In the teaching of mathematics emphasis should be more on the understanding of basic principles than on the mechanical teaching of mathematical computations'. Commenting on the then prevailing situation in schools, it observed that 'in the average school today instruction still conforms to a mechanical routine, continues to be dominated by the old besetting evil of verbalism and therefore remains as dull and uninspiring as before'.

The National Policy on Education (1986) has also considered the importance of mathematics in general education and suggests that 'mathematics should be visualized as the vehicle to train a child to think, reason, analyze and to articulate logically. Apart from being a specific subject it should be treated as concomitant to any subject involving analysis and reasoning'. In the recent past there have been tremendous developments in theories of learning and the science of teaching. Though mathematics occupies a place of importance, the researches in this area have been scanty.

The present trend report is based on 70 studies and project reports. These included studies which have been reported in the *Third Survey of Research in Education* (Buch, 1987). The studies and project reports in mathematics education reviewed below have been classified into the following four categories:

A. Teaching and Teacher Behaviour
B. Curriculum and Textbooks
C. Factors Affecting Achievement
D. Diagnostic and Other Tests in Mathematics

A. TEACHING AND TEACHER BEHAVIOUR

A good deal of research had gone into methods/strategies of teaching mathematics. The effect of methods has been evaluated on a variety of variables. They include personality types, achievement, intelligence, level of thinking, sex, concept attainment in mathematics, motivation and reasoning ability, general mental ability, self-concept, attitude towards mathematics, and mathematical creativity, knowledge, understanding and application aspects of learning, study habits, etc. The following methods have been tried out: individualized instruction, lecture-discussion, inductive-discussion-drill, auto-instruction-group-discussion, Ausubel's and Bruner's strategies, expository, guided discovery and pure discovery methods, visual projection, programmed learning, activities and experiments, symbol picture logic programme, mastery learning, analytico-synthetic and tell-and-do methods.

Girdhari Lal (1986) studied the effects of individualized and conventional instruction and found that individualized instruction was more effective in terms of mathematics achievement. In his study, Chitkara (1985) found lecture-discussion strategy better suited for below average ability extraverts and intraverts while inductive-discussion-drill and auto-instruction-group-discussion suited the high ability extraverts and high ability intraverts, respectively. Expository and discovery methods were tried out in respect of mathematics achievement and mathematical creativity. Mohammad Miyan (1982) found that the guided discovery method was most effective in developing originality as compared with the tell-and-do and pure discovery methods. Bhalwankar's (1985) study revealed that in the case of a high intelligence group, the expository method was more effective than the guided discovery method on application objective. But, for low intelligence children, the guided discovery method was more helpful on retention of application objective.

Gupta (1979) discovered that the analytico-synthetic method was more effective than the traditional (narration–explanation) method in terms of overall geometry achievement of class IX; for class VIII they did not have any differential effect. Several researchers in the field developed programmed learning material and evaluated its effectiveness in terms of achievement and psychological correlates (Pandey, 1980; Seshadre, 1980; Shah, 1980; Inamdar, 1981; Sharma, 1981; Davies, 1982; Rao, 1983; Kothari, 1985). Programmed instruction was more effective than conventional teaching not only in relation to achievement but also in relation to retention (Sharma, 1981). Programmed instruction also found favour with flexibles while rigids benefitted more by conventional teaching. In a similar study (Rao, 1983) it was found that programmed learning was superior to conventional learning insofar as achievement was concerned; programmed learning was suited to urban subjects, higher grade students, subjects of privately managed schools and subjects of high general mental ability. But programmed learning was found inferior to methods involving visual projection and activities and experiment (Kothari, 1985) in respect of achievement. Further visual projection, activity and experiment and programmed learning methods were equally good and sometimes superior in respect of different content areas in mathematics. Conceptual understanding of mathematics has been the concern of educators, particularly those at the school level. Ausubel's model, Bruner's model and mastery learning have been examined. Chitriv (1983) found that Ausubel's advance organizer model and Bruner's concept attainment model were superior to the traditional method in knowledge transfer, heuristic transfer, short-term retention and long-term retention of concepts. The advance organizer model benefitted categorical style students, while the concept attainment model did not have a varying effect on different style preferences. As far as the mastery learning model is concerned (Yadav, 1984), it was found superior to the traditional in respect of mathematic achievements, attitude towards mathematics and improving self concept.

Symbol Picture Logic Programme (SPLP) was developed by Vyas (1983) and its effects were seen on mathematics achievement; this programme made students active participants in the thinking process. Feed-back was also used in the development and retention of rational understanding of students of both sexes and of different age groups (Shastri, 1984).

Teacher preparation techniques is an area which did not attract researchers much. A few studies tried out microteaching technique in developing instructional competence in mathematics teachers and skills in teaching modern mathematics. Bailker's (1983) study revealed that a self-instructional remedial microteaching course improved the instruc-

tional competence of the teacher in respect of some selected skills, the course also had a lasting effect. Skills appropriate to teaching modern mathematics were isolated by Pratap (1982). Microteaching was more effective in the development of these skills in comparison with traditional method. But the effect of the two methods on attitude towards teaching of the subject did not differ. Major skills in teaching mathematics, namely skills of developing a concept, a principle, applying an inductive approach, applying a deductive approach, applying a problem solving approach and figure drawing were isolated. Teachers trained in these skills, through microteaching, were superior on a mathematics teaching competency scale to their counterparts trained through the traditional approach (Shukla, 1981). Kirkire (1981) analysed the impact of objective-based lesson plans on behaviour of teachers and pupils' achievement in mathematics which yielded no differential effect when compared to other types of lesson plans. Dev (1979) surveyed the schools of Nagaland with a view to finding out teaching methods popular with mathematics teachers. He discovered that teachers were more interested in the lecture method and had a negative attitude towards reflective type questioning. A method/strategy is not universally superior or inferior to the others in respect of content, objectives, grade levels and intelligence. There has to be a systematic effort to develop a hierarchy of content, methods, etc.

In a project, the GCPI (1976) investigated the lesson plans of student teachers with a view to finding out the nature of questions asked to evaluate the lesson: knowledge type questions were given prime importance while questions relating to the application aspect were neglected. A look at the research studies in the methodology of teaching and teacher preparation reveals the need for concerted efforts to try out models of teaching in various areas and at all levels of schooling.

B. CURRICULUM AND TEXTBOOKS

Research in the area of curriculum has a long way to go. There is no systematic evaluation of curriculum in general and textbooks in particular. Curricula in the Indian context have been developed on the basis of the experience of experts supplemented by scanty research evidence. Developed countries are going in for sophisticated and utilitarian stuff in mathematics while developing ones, including India, are tending to adopt the essence of modern thinking on curriculum which caters to the needs of many. The main aim has been to develop a society which is transforming itself into an industrial and technological society, wherein mathematical literacy is essential for every child. Giri (1977) compared curriculum development in India and in developed countries. Aram (1986) compared mathematics education in India and the People's Democratic Republic of Yemen in respect of objectives, curriculum, content, textbooks, teaching methods, evaluation and teacher education.

Mathematics constitutes the core curriculum of several professional courses. The utility of mathematics content in such professional courses has also been of concern to researchers. Bhat (1984) studied the existing syllabus of mathematics with a view to seeing its relevance to the jobs of technicians and discovered that solving simple trignometric equations was not relevant to any branch; approximately twenty mathematical competencies relevant to the core curriculum were identified. Paranjape (1977) traced the changes in the objectives of mathematics teaching in primary schools in Maharashtara since 1901, observing that the changes occurred in favour of laying a firm foundation for higher mathematical education. Modern mathematics has also attracted the attention of many researchers. The effective teaching of modern mathematics has been a matter of concern/anxiety for educators as well as for teachers who found it difficult to present the concepts in modern mathematics. Vincent (1982) conducted 20 seminars and workshops in order to develop devices which could be used to teach modern mathematics from standard I to X. The relevance of modern mathematics to the development of students' abilities has been studied by Bansal (1979) who compared abilities like critical thinking and divergent thinking of students taught modern mathematics and those taught traditional mathematics. Of course he has very objectively exercised control over the two groups in respect of the variables that would affect the criterion variables. The results were in favour of modern mathematics. Bala (1980) has also compared the effects of modern mathematics and traditional mathematics on Piagetian concrete and formal logical thinking. She found that a modern mathematics curriculum facilitated Piagetian cognitive thinking ability to a greater extent than a traditional mathematics curriculum. Since research evidence seems in favour of modern mathematics, teacher preparation needs to be strengthened in this aspect; and teachers should also be made aware of effective methods to popularize modern methematics through more

inservice programmes.

Textbook structure has been considered identical to syllabus or even curriculum structure for quite some time now. Only of late has the concept of curriculum been rightly understood by schoolteachers. It is still feared that teachers in schools in remote areas are not yet able to distinguish between syllabus and textbook; and no doubt, textbooks are so written as to encompass the entire syllabus. There are few states in which syllabus and textbooks have been the focus of attention of researchers in mathematics education. A look at researches in this area during a little over one and a half decades reveals that the states of Kerala and Maharashtra are leading, followed by Haryana, Andhra Pradesh and Rajasthan. Gopalakrishna (1977) critically analysed the syllabus and textbooks in upper primary classes in Kerala. Another study in Kerala by Lalithamma (1981) attempted to develop criteria for writing and evaluating textbooks in mathematics prescribed for secondary schools. Walavalkar (1971) studied, critically, the mathematics textbooks in primary schools of Maharashtra and found that the text material had relevance to daily life and was suited to the capacity of the pupils. He also suggested rectification of some minor faults and re-sequencing of some of the topics in the textbooks for standard II and standard III. Sharma (1975) in his analysis of textbooks, prescribed for delta class in Rajasthan stated that the syllabus in mathematics was highly defective, outmoded and wanting in a proper process of evaluation. He also pointed out that there was no relationship between the course-content prescribed in the syllabus and that presented in the textbooks. Primary schoolteachers' views about the mathematics syllabus in Maharashtra were studied through a project of the MSBTPCR (1974). It was revealed that a majority of teachers found the modern mathematics portion of the syllabus difficult. Krishna Kumari and others (1980) collected views of primary school teachers teaching standard II on textbooks as a tool for teaching. An analysis of their views indicated that only a small percentage of teachers go through the textbooks thoroughly and assimilate concepts and methods included in them. In a project, SCERT, Andhra Pradesh (1981), evaluated the textbooks prescribed for classes VI and VII and also analysed the views of parents, teachers and students about these textbooks. By and large, parents, teachers and students found continuity in the development of content in mathematics textbooks. Parents felt unable to help their wards in solving problems included in mathematics textbooks. Since textbooks are generally the only tool in the hands of teachers as well as students it is needless to emphasize that there is need to analyse textbooks at all levels of schooling with a view to finding out their relevance to objectives, content, methodology, feedback, etc.

C. FACTORS AFFECTING MATHEMATICS ACHIEVEMENT

Achievement in mathematics has been studied in relation to a number of variables, both cognitive and affective. Studies in the past decade have confirmed that intelligence and socio-economic background are major contributors to mathematics achievement (Singh, 1986; Nilima Kumari, 1984; Rajput, 1984; Gakhar, 1981; Jabbal, 1981; Kabu, 1980; Nalinidevi, 1976). Factors responsible for poor achievement or failure have also caught the attention of researchers. Mainka (1983) found language mastery was an important factor in the acquisition of concepts in mathematics. Nilima Kumari (1984) studied the conservation of number and substance in relation to intelligence and SES, revealing significant positive relationships. Reasoning power, space visualizations, attitude towards mathematics were found significantly related to mathematics achievement (Patel, 1984). In Rajput's (1984) study, achievement motivation was found to have no bearing upon achievement. Gakhar (1981) identified variables of educational environment as responsible for acquisition of mathematical concepts. Apart from SES and intelligence, variables like teachers' qualifications, class size, encouragement to teacher by the head, use of audio-visual aids, and feedback were found significantly related to acquisition of mathematical concepts. Nalinidevi (1976) studied the development of the number concept and found that discrimination, seriation and numeration among children appeared in that order. Katiyar's (1979) study revealed that boys and girls did not differ in mathematics achievement. Also, numerical reasoning and numerical ability occupied a prominent place among the five cognitive functions studied in relation to mathematics achievement. Affective variables were seen to possess the ability to discriminate between the extreme achievement pairs as against more approximate pairs (Soman, 1977). Singh (1986) found attitudes to be related to mathematics achievement.

Causes of under and low achievement in mathematics vary from defective textbooks to some personality needs. Imparting of limited knowledge, blind use of

rules, defective textbooks, insufficient drill work, absence of methodical approach were some of the causes of low achievement in schools of Assam (Sharma, 1978). Factors predominant among failures studied by Jain (1979) were mathematical background, attitude towards mathematics and low motivation. Gadgil (1979) also studied the causes of failures at the SSC examination (standard X) and found that school factors like inadequate coverage of the syllabus, inadequate attention to difficult topics and a personal factor, namely, lack of motivation had been responsible for failures. Factors responsible for underachievement in mathematics have been some personality variables, namely, self reliance, sense of personal freedom, feeling of belongingness, withdrawing tendencies, nervous symptoms, social skills, general anxiety and test anxiety, parental profession and parental education (Iyer, 1977). Personality variables were also studied by Somasundran (1980) in relation to over and under-achievement. Test anxiety, general anxiety and masculinity were negatively related to mathematics achievement. All personality variables except the sense of personal worth, sense of personal freedom, withdrawing tendencies (freedom from) and community relations discriminated between overachievers and non-overachievers. Koul's (1978) study found that high and low achievers in mathematics differed significantly on eight of Murray's needs. The low achievers in mathematics were more exhibitory, succorant, heterosexual and aggressive. High intelligence, numerical ability, abstract reasoning and adjustment were some of the characteristics of mathematically gifted children (Kalra, 1979; Kabu, 1980). Kalra also found that the mathematically gifted were quite high on creativity. In another study on mathematical creativity, aptitude and attitude, Tuli (1979) found aptitude for mathematics and achievement in mathematics were significanlty and positively related to mathematical creativity.

Factor analysis of abilities having a bearing on mathematics achievement was also undertaken by a number of researchers. Achievement in mathematics as a whole and that in algebra, arithmetic and geometry and in some specific topics in algebra, concepts of sets and functions were also factor analysed. In her study, Kaur (1985) analysed abstract concepts in mathematics and isolated the figural angular factor and numerical facility factor as the dominant factors in the case of high school students and in the case of students of B.Sc. first year and third year, the dominant factors were figural angular ability, symbolic number ability for the former and triangular figural relation ability and numerical ability factors for the latter. The ability to learn the number system is chiefly composed of factors: general intelligence, number factor and perceptual factor (Mondkar, 1984). Numerical aptitude and some of the abilities of Guilford's structure of intellect were analysed and their bearing on mathematics achievement studied. Dubey (1987) found numerical reasoning, numerical facility and visualization of numerical patterns as common factors of numerical aptitude tests, the maximum contribution, 27.95 per cent, being from numerical reasoning. Number correlates, arithmetic operational sequence and numbers group property were the best predictors of achievement in mathematics. General algebraic reasoning was identified as the only factor common to tests in algebra (Chauhan, 1982). Among eight tests of SI 'education of correlates' was the only common factor. When the tests of algebra and SI were combined, two factors: general algebraic reasoning and pattern visualization were identified; a little variation existed when the samples of boys and girls were analysed separately. Tiwari (1986) in a similar study analysed 19 tests of reasoning ability and six tests of set concept. The study revealed two dominant factors, namely cognition of semantic implication and convergent production in the case of the reasoning ability test and in the case of the set concept test the dominant factors identified were: concepts of sets and concepts of functions. Factor analysis of 19 reasoning ability tests and composite set concept achievement tests revealed a significant loading on deductive reasoning.

D. DIAGNOSTIC AND OTHER TESTS IN MATHEMATICS

Attainment in mathematics is very much based on the mastery of fundamental skills. This has been an area of interest for educators in mathematics. Schonell's Diagnostic Arithmetic Tests still continue to be the best. Efforts have been made in respect of providing remedial measures. There is hardly any study which does not show an effect of remedial teaching/measures. Researchers like Das and Barua (1968), Rastogi (1983), Sinha (1971) and Thakore (1980) have constructed diagnostic tests and suggested remedial measures for specific weaknesses in arithmetic.

Attitude towards mathematics does affect achievement in mathematics. Several investigators have developed scales to measure attitude towards mathematics and also discovered a relation between attitude and

achievement. Kolhe (1985) compared boys and girls and urban and rural population on attitude towards mathematics and indicated significant differences between the attitudes of urban and rural students towards mathematics irrespective of sex. Mishra (1978) developed a scale to measure attitude towards mathematics and indicated a relationship of attitudes with some socio-economic factors. Children from better homes had a favourable attitude when compared to children from poor homes.

Tests in mathematical creativity have also been developed. Mohammad Miyan (1982) constructed a test of mathematical creativity for students of class IX which included abilities to analyse, determine patterns, see likenesses and differences and application. Parasnis (1985) standardized a test (in Marathi) for measuring creativity of class X students. According to the author, creativity in mathematics is measurable in terms of five factors, namely, visualization, reorganization, judgement, number fluency, and divergent production.

Ketkar (1982) developed unit tests in mathematics for class VIII for Marathi-medium students and found that urban boys and girls scored better than their rural counterparts; the reliability coefficient of the tests ranged from 0.77 to 0.88. With a view to having a picture of general mistakes committed by students in answering questions, Sali (1978) analysed answer-books of mathematics and English of the secondary school leaving examination and found that transposition, forming equations, solving equations with coefficients and fractions, etc., were the areas of common mistakes in algebra; the common errors in geometry were writing figures, using theorems on perpendicular bisector of chord, applying Pythagoras theorem, properties of isosceles triangles, etc.

There has been little effort on the part of researchers and organizations to develop and standardize tests and other measuring instruments. Though attitude towards mathematics seems to be positively related to achievement, no effort has been made to investigate how that attitude is formed.

CONCLUDING REMARKS

A close analysis of the nature, type and quality of studies throws adequate light on the status of reasearch in mathematics education. It is very clear that the quality of researchers completed in the four major areas delineated in the preceding pages does not seem to be encouraging and leaves much to be desired. The major issues before teacher educators in mathematics are in-depth study of the mathematics curriculum, curriculum renewal, refining teaching methods in mathematics in the light of the advances in the science of pedagogy on the one hand and educational technology on the other. Currently, the scope of the study remains limited and the validity of conclusions remains restricted. What is needed is a proper selection of problems, specially in the area of methods of teaching mathematics, planning long-term studies, trying out various methods of teaching and measuring multi-dimensional outcomes among students as a result of the teaching exercise. After all, each method of teaching has its limits in developing abilities and skills among students with respect to various branches of mathematics.

ABSTRACTS: 785—807

*785. BHARDWAJ, R.P., *Standardization of a Comprehensive Diagnostic Test and Preparation of Remedial Material in Mathematics for Middle Standard Students of Haryana,* Ph.D. Edu., Kur. U., 1987

The objectives of the study were (i) to construct and standardize a diagnostic test in mathematics for middle standard students of Haryana, (ii) to find out the types of errors committed by the pupils in the context of the nature of teaching units, and (iii) to construct and try out remedial material.

The test was standardized on a sample of 1146 students (729 boys and 417 girls) belonging to government and aided high schools of Haryana State. The items of the test were selected from the syllabus of mathematics prescribed by the Haryana Education Board for the middle standard examination. The items were analysed for their clarity of direction, gradation, discriminatory value and appropriateness of content. The reliability was established through the test-retest method and validity was established through content validity, intrinsic validity and criterion related validity. On the basis of the diagnostic test, 377 programmed self-instructional exercises (117 demonstrated, 117 promoted and 143 released) were prepared.

The main features of the test and remedial material were : 1. The test consisted of three parts, that is, arithmetic, algebra and geometry, comprising 202, 138 and 158 items respectively. There were supply type items for arithmetic and algebra and multiple choice items for geometry. 2. The reliability established through the test-retest method had a coefficient ranging from 0.81 to 0.91 for each of the three areas and the whole test. 3. Intrinsic validity of the test for all the three areas and the whole test ranged from 0.90 to 0.95. 4. Validation of the test against students' marks in mathematics in the public examination conducted by the Haryana Board of Education gave a value of 0.83. 5. The items in the test were scored by giving one mark for each correct response and zero mark for each incorrect response. 6. Percentile norms were established and the scores were categorized in five-fold categories ranging from very good to very poor. 7. The error rate in all the three areas, that is, arithmetic, algebra and geometry, came out to be 30.4 per cent, 50.6 per cent and 51.4 per cent respectively. 8. All programmed exercises could be completed by the students in six days taking four to five hours daily. 9. There was significant improvement in achievement of the students after they had gone through the remedial exercises.

786. BHAT, N.R., *To Formulate Objectives and Select Content for a Core Curriculum in Mathematics for Technicians,* Ph.D. Edu., SGU, 1984

The major objectives of the study were (i) to find out whether the content and objectives in mathematics for diploma courses in civil/mechanical/electrical engineering in the southern states of India were sufficiently comprehensive to meet the needs of students to understand the technical subjects of the curriculum and perform technician jobs in industry, (ii) to analyse the objectives and content relevant to students of different branches, (iii) to identify competencies in mathematics relevant to a core curriculum in technician mathematics, and (iv) to develop a format for developing curriculum materials to achieve the competencies.

The sample consisted of about 150 engineering teachers, with roughly equal numbers in each branch, (civil, mechanical and electrical) taken from four government and six private polytechnics in Tamil Nadu which were randomly selected. A questionnaire was prepared to collect the data. The design of the study comprised preparing a validated list of topics for a potential curriculum in mathematics for technicians, identifying relevant mathematical competencies to be included in the core curriculum from the point of view of meeting the needs of students to understand the technical subjects of the curriculum and of technicians in doing their jobs, preparing a document listing the mathematical competencies identified for inclusion in the core curriculum, arranged into suitable units and expanded into enabling content objectives, and preparing a model curriculum on one unit and trying it out.

The major findings and outcomes of the study were: 1. A list of 31 mathematical topics was validated for inclusion in a potential curriculum in mathematics for technicians. 2. Only some basic topics in algebra, trigonometry and analytical geometry could be considered as essential for technicians to perform their jobs in industry and the need for various topics in mathematics in a technical course should, therefore, be considered mainly from the point of view of students, requirements for understanding the technical subjects of the curriculum. 3. Out of a total of 27 mathematical competencies

formulated to cover 31 topics identified earlier, 20 mathematical competencies were identified as relevant for a core curriculum in technician mathematics, common to civil, mechanical and electrical engineering branches. 'Solve Simple Trigonometric Equations' was considered not relevant to any of the branches. 4. A document consisting of 20 mathematical competencies identified as relevant for a core curriculum in technician mathematics which was expanded into enabling content objectives (general and specific) and arranged into 17 units was the final outcome. 5. The approach used for implementing a competency-based curriculum in one unit led to better performance of students as compared to the traditional method and was found to be adequate and useful by the clientele.

*787. BHATTACHARYA, M., *An Investigation into the Learning Disabilities Developed by Secondary School Students in the Area of Equation-Sums in Algebra*, Ph.D. Edu., Kal. U., 1986

The major aims of the study were (i) to conduct a survey of the learning disabilities developed by the beginners reading in secondary schools under the West Bengal Board of Secondary Education in linear equation, (ii) to conduct a scientific experiment on the effectiveness of two mathematical methods for prevention of learning disabilities usually developed by beginners in linear equation-sums in one unknown in algebra, and (iii) to provide from the results of the experiment a satisfactory mathematical method for beginners for solution of linear equations.

In order to study learning disabilities developed by secondary school students in the area of equation-sums, the hypotheses were: (1) Students develop more learning disabilities in the understanding of linear equation-sums in one unknown than in the knowledge of solving such sums. (2) Students develop more learning disabilities in the application of linear equation-sums in one unknown than in the understanding of such sums. (3) Students develop more learning disabilities in the application of linear equation-sums in one unknown than in the knowledge of solving such sums. (4) The simplified method is more effective than the method of transposition for the development of knowledge of students in solving linear equation-sums in one unknown. (5) The simplified method is more effective than the method of transposition for the development of understanding of students in linear equation-sums in one unknown. (6) The simplified method is more effective than the method of transposition for the development of applicational ability of students in linear equation-sums in one unknown.

A diagnostic pre-test on linear equations in one unknown and three diagnostic tests on knowledge of solving, understanding, and application of the same were prepared and standardized on 400 class VIII students. The final forms were administered on 1000 class VIII students of 24 randomly selected schools of Hooghly and 24-Parganas districts. Afterwards 400 scripts were randomly selected. Objectivity, test-retest reliability, content and criterion related validity were determined. Lesson units were prepared and the experiment was carried out in for randomly selected Bengali medium schools in Hooghly district. Control and experimental groups of equal size were set up in each school. In all, 200 class VIII students were finally included in the experiment. Analysis of covariance design of duplicated experiments was followed; t-test was also used.

Some of the major findings were that hypotheses Nos. (1), (3), (4), and (6) were retained; and (2) and (5) were rejected. The tests were reliable and valid.

788. CHITKARA, M., *To Study the Effectiveness of Different Strategies of Teaching on Achievement in Mathematics in Relation to Intelligence, Sex and Personality*, Ph.D. Edu., Pan. U., 1985

The objectives of the study were to find out (i) whether achievement in mathematics was affected by different strategies of teaching, (ii) whether different strategies had differential effects on achievement of male and female students, (iii) whether levels of intelligence interacted with teaching strategies in terms of achievement, and (iv) whether personality acted as a potential factor in selection of teaching strategy.

In the study a pretest/post-test experimental design was followed. A four-way factorial design ($3\times2\times2\times3$) was employed. The independent variables in the study included strategies of teaching, sex, personality and intelligence and the criterion variable was achievement in mathematics. The strategies of teaching varied in three ways—(a) lecture-discussion, (b) inductive-drill and (c) auto-instruction group discussion. The personality varied in two ways—extraverts and introverts; the variable of intelligence had three levels—low, average and above average. A sample of 300 students was randomly selected from grade IX students of four schools of Chandi-

garh. The sample subjects were administered (i) The Mathematics Achievement Test, (ii) The Jalota Group Test of Mental Ability (1972), (iii) The Eysenck Personality Inventory (1964). The students were divided into three groups of 100 each. One group was taught mathematics through lecture-discussion, the second group was taught mathematics through inductive-drill and the third group was taught mathematics through auto-instruction group discussion. The data collected through pretest/post-test were analysed through four-way (3×2×2×3) analysis of variance.

The findings of the study were: 1. All the three strategies, namely, (a) lecture-discussion, (b) inductive-drill, and (c) auto-instruction group discussion, were found to be equally effective in terms of achievement in mathematics disregarding levels of intelligence, sex and personality type. 2. Boys and girls of superior ability did not show any significant difference between their mean scores on achievement in mathematics. 3. Girls of average ability scored significantly higher in mathematics than boys of average ability. 4. Lecture discussion strategy found favour with average ability students as they scored significantly higher than above-average and below-average groups. 5. Strategy II and strategy III, namely inductive-drill and auto-instruction group discussion, was more suited to the students having above-average intelligence than average and below-average intelligence. 6. The strategy of lecture-discussion was found to be equally effective with above-average and below-average ability (intelligence) introverts as well as extraverts. 7. Extraverts of high ability, average ability and below-average ability scored equally well when taught through strategy I. 8. Under the strategy of inductive-drill, average-ability extraverts scored significantly higher than average-ability introverts. 9. Under the strategy of auto-instruction group discussion, high ability and low ability extraverts did not differ from the high ability and low ability introverts. But extraverts of average ability differed significantly in their achievement from average ability introverts. 10. Out of the three strategies, strategy I was more suited for below-average ability extraverts and introverts, strategy II for high ability extraverts and strategy III was most suited for high ability introverts for achievement in mathematics.

789. CHITRIV, U.G., *Evaluating Differential Effectiveness of Ausubel and Bruner Strategies for Acquisition of Concepts in Mathematics*, Ph.D. Edu., Nag. U., 1983

The major objectives of the study were (i) to ascertain the comparative effectiveness of the Ausubel strategy with the traditional one of the various criteria of concept acquisition in mathematics, (ii) to ascertain the comparative effectiveness of the Burner strategy with the traditional one on the various criteria of concept acquisition in mathematics, (iii) to ascertain the relative effectiveness of the Ausubel and Bruner strategies on the various criteria of concept acquisition in mathematics, (iv) to ascertain the effectiveness of the Ausubel strategy in the acquisition of concepts in mathematics, separately for the students of different conceptual style preferences, (v) to ascertain the effectiveness of the Bruner strategy in the acquisition of concepts in mathematics, separately for the students of different conceptual style preferences, (vi) to ascertain the relative effectiveness of the Ausubel and Bruner strategies in the acquisition of concepts in mathematics, separately for the students of different conceptual style preferences.

The sample consisted of three intact sections of grade XI chosen from higher secondary schools of Nagpur City on the basis of their comparability in respect of size, age, mean score in mathematics at the S.S.C. examination and dispersion of these scores. Treatments were randomly assigned to these three sections. Six concepts were chosen from the mathematics syllabus for grade XI students of the science stream. Twenty-five lessons were prepared by each of the three strategies—Ausubel strategy, Bruner strategy and traditional strategy. Lessons of the Ausubel strategy followed the operational form of Ausubel's Advance Organizer Model; lessons of the Bruner strategy followed the operational form of Bruner's Concept Attainment Model. The tools used were Raven's Standard Progressive Matrices, Cognitive Style Test of Robinson and Gray, Previous Knowledge Test and other criterion tests developed by the researcher. In addition, an Observer's Rating Scale to measure 'Teacher Fidelity' was also used. Non-equivalent Control Group Design was chosen for the study.

The major findings were: 1. The Ausubel strategy was superior to the traditional strategy for teaching mathematical concepts to eleventh grade students, so far as knowledge transfer and heuristic transfer of the concepts were concerned. 2. The Bruner strategy was superior to the traditional strategy for teaching mathematical concepts to eleventh grade students, so far as knowledge, heuristic transfer, short-term retention and long-term retention of the concepts were concerned. 3. Ausubel and Bruner strategies were equally effective for teaching mathematical concepts to eleventh grade students so far as students' ability to acquire knowledge of

the concepts was concerned. 4. The Ausubel strategy was superior to the Bruner strategy for teaching mathematical concepts to eleventh grade students, so far as enhancing concept transfer was concerned. 5. The Bruner strategy was superior to the Ausubel strategy for teaching mathematical concepts to eleventh grade students, so far as students' abilities to transfer heuristics, discover new relationships, and to retain knowledge of the concepts learnt for short as well as long periods of time were concerned. 6. Conceptual style preferences of the students seemed to have a differential effect on their acquisition of mathematical concepts, when taught by the Ausubel strategy. This strategy appeared to be more suitable for teaching mathematical concepts to categorical style students of the eleventh grade. 7. Conceptual style preference of the students did not seem to have a differential effect on their acquisition of mathematical concepts, when taught by the Bruner strategy. This strategy appeared to be suitable for teaching mathematical concepts to eleventh grade students of all conceptual style preferences.

790. DAS, R.C. and BARUA, A.P., *Effect of Remedial Teaching in Arithmetic, A Study with Grade IV Pupils*, SIE, Assam, 1968

The main aim of the study was to determine the effect of remedial teaching in arithmetic in grade IV.

For the purpose of diagnosis of individual differences F. J. Schonell's 'Diagnostic Arithmetic Tests' were adopted. The first seven series of tests were used. There were altogether 604 sums. Pretest post-test experimental-control group design was followed. In each group there were 30 grade IV pupils. The experimental group was given remedial teaching and the control group was taught as usual by the class teacher. Student t-test was applied to compare test-wise and total average achievement of both the groups.

The major conclusion of the study was that remedial teaching had definitely improved significantly the achievements in arithmetic.

The major educational implication of the study is that remedial teaching, even for a small period compared to the total duration of working days in the year, can effect significant improvement in achievement in arithmetic.

*791. DORASAMI, K., *Development of a Competency-Based Curriculum Design for Methodology of Teaching Mathematics and its Validation*, Ph.D. Edu., Mys. U., 1986

The main objectives of the study were (i) to identify the major weaknesses in the existing methodology courses in mathematics with regard to the development of competencies, skills and attitudes required of a mathematics teacher, (ii) to develop a competency-based curriculum (CBC) design in the methodology of teaching mathematics at the secondary school level, and (iii) to validate this design empirically with particular reference to (a) cognitive abilities in the methodology of teaching mathematics, (b) attitude towards various aspects of training, and (c) teaching performance of student teachers.

This was an experimental study. For measuring the cognitive abilities of student teachers in the methodology of teaching mathematics, a criterion-referenced achievement test was developed. In order to measure the attitudes of student teachers towards the different aspects of training, an attitude scale was developed following the Likert method. The teaching performance of student teachers during internship in teaching was assessed using the student teaching profile developed and used by the RCE, Mysore. The sample for this study was chosen from the B.Ed. students in the RCE, Mysore. It included 48 students who offered methodology of teaching mathematics as a specialization subject in their B.Ed. course. They were formed into two equivalent groups on the basis of the percentage of total marks secured in all the subjects in their degree examination. The percentages of aggregate marks of the student teachers were arranged in a descending order and pairs of student teachers were generated from this list. The student teachers securing the lowest and the next lowest percentage of marks in the list formed a pair. This procedure was followed until 23 pairs were formed. Then one member of each pair was placed in the experimental group and the other in the control group. The experimental group was exposed to the competency-based curriculum in the methodology of teaching mathematics developed by the investigator, and the control group to the existing methodology course followed in all the affiliated colleges of education in the university of Mysore. Each group received instruction for six periods a week and each period's duration was 55 minutes. Both the groups were also exposed to a core skills programme intended to develop basic skills in teaching and general

principles of evaluation. They received instruction for two periods in pedagogy and practical work in a block of two periods in a week in the first semester. In the second semester internship teaching experience was provided for both the groups for five weeks. The criterion-referenced achievement test was administered to both the groups before and after treatment to measure the individual competencies and overall competency of the student teachers. Attitude scales were administered to these two groups to measure their attitudes towards different aspects of training. The RCEM student teaching profile was used to assess the teaching performance of student teachers of both the groups during internship. The data thus collected were analysed employing appropriate statistical techniques like binomial test, Z-test and t-test.

The major findings were: 1. The CBC in general was found to be more effective than the existing curriculum in developing cognitive competencies in the methodology of teaching mathematics, attitudes towards various aspects of training of mathematics teachers, and teaching competence. 2. The CBC had developed mastery of 15 out of 20 competencies in at least 60 per cent of student teachers, whereas the existing curriculum could develop mastery in only two competencies. 3. The CBC could develop overall competency (mastery of at least 60 per cent of the competencies measured) in about 69 per cent of student teachers as against the almost negligible percentage of such student teachers with the existing curriculum. 4. The proportion of masters in the experimental group was significantly greater than that of the control group in 14 individual competencies and overall competency. 5. The CBC could develop a significantly favourable attitude towards all the training aspects as against the existing curriculum which had developed a significantly favourable attitude towards all the training aspects except lesson planning. 6. The CBC had developed a more positive attitude towards lesson planning, the methodology course and training in general than the existing curriculum. 7. The CBC and existing curriculum seemed to be equally effective in the development of a positive attitude towards lesson observation and student teaching. 8. The student teachers who were exposed to CBC demonstrated better teaching performance than those who followed the existing curriculum. The overall teaching performance of the experimental group was found to be influenced more by the performance on lesson planning.

792. DUBEY, V.K., *Factorial Nature of Numerical Aptitude and its Bearing on Mathematical Learning*, Ph.D. Edu., BHU, 1987

The objectives of the study were (i) to find out the number and nature in terms of psychological constructs of basic factors underlying numerical aptitude, (ii) to study the contribution of these factors underlying numerical aptitude, to the achievement in arithmetic, algebra and geometry, and (iii) to study the contribution of these factors underlying numerical aptitude to achievement in mathematics, the score in mathematics being determined by combining scores in arithmetic, algebra and geometry.

The aggregate of all the students studying in class X of high schools and intermediate colleges of Varanasi formed the population. The sample comprised 300 students of class X selected from eight intermediate colleges. The tools used were Numerical Aptitude Test (N.A.T.) and Achievement Test in Mathematics (A.T.M.). N.A.T. comprised 12 sub-tests. Each sub-test contained ten homogeneous items. The reliability coefficient of this test was 0.97. A.T.M. comprised three sub-tests each in arithmetic, algebra and geometry. The reliability coefficient of this test was 0.89. The data were collected with a condition that all the tests must be administered on the same subjects. If a subject took one of the tests, it was essential for him to take the other tests also. The data were factor analysed.

The major findings were: 1. All the sub-tests of N.A.T. were significantly correlated with one another. 2. The factor analysis of 12 sub-tests of the Numerical Aptitude Test-Battery resulted in the emergence of three common factors, namely, 'Numerical Reasoning', 'Numerical Facility', and 'Visualization of Numerical Patterns'. All the three factors accounted for 57.88 per cent of variance in the total set of 12 variables with 27.95 per cent contributed by the factor 'Numerical Reasoning', 16.94 per cent by the factor 'Numerical Facility' and 12.99 per cent by the factor 'Visualization of Numerical Patterns'. 3. The first factor 'Numerical Reasoning' was best represented by four sub-tests of numerical aptitude, namely, Arithmetic-Operational Sequence, Number Relations (Operational), Number-Correlates (Digital) and Group-Member-Identification, all based on, more or less, the ability to find relationships and correspondence in the numerical situations. The percentages of variance explained by the Factor I in the tests which represented it were 59.08 per cent, 51.94 per cent, 44.50 per cent, and 40.24 per cent respectively.

4. The second factor, namely 'Numerical Facility' was characterized largely by the sub-test Number Operations which was purely a test of computational ability using four fundamental operations of arithmetic. The sub-test Number-Group-Property also gave significant loading in this factor. The percentages of variance explained by the factor in the sub-tests which represented it were 56.54 per cent and 42.95 per cent respectively. 5. The third factor, namely, 'Visualization of Numerical Patterns' was characterized by sub-tests Problem-solving and Number-Matrices which were based on recognizing implicit numerical systems or patterns. The percentage of variance explained by the factor in the sub-tests which represented it were 62.08 per cent and 58.56 per cent respectively. 6. The multiple regression analysis of the achievement test in arithmetic on the sub-tests of the Numerical Aptitude Test Battery revealed that three sub-tests, namely, Group-Member-Identification, Number-Matrices and Number-Group-Property were found to be the best predictors of achievement in arithmetic. The total variance explained by these sub-tests was, however, only 9.34 per cent. 7. The multiple regression analysis of the achievement test in algebra on the sub-tests of the Numerical Aptitude Test Battery revealed that three sub-tests, namely, Arithmetic-Operational Sequence, Number-Correlates (Operational) and Number Operations, were the best predictors of achievement in algebra. However, the total variance explained by these three sub-tests was only 17.19 per cent. 8. On the basis of multiple regression analysis of the Achievement Test in Geometry on the sub-tests of the Numerical Aptitude Test Battery, it was found that only two sub-tests, namely, Arithmetic-Operational Sequence and Number-Correlates (Digital) were the best predictors of achievement in geometry. However, the total variance accounted for by the combination of these two tests was found to be 7.50 per cent of total variance. 9. When the multiple regression analysis of total scores in the combined Achievement Test in Mathematics on sub-test of the Numerical Aptitude Test Battery was conducted, it was found that three sub-tests, namely, Number-Correlates (Operational), Arithmetic-Operational Sequence and Number-Group-Property were the best predictors of achievement in mathematics. The total accountable variance explained by these three sub-tests was 16.60 per cent. 10. The multiple regression analysis of arithmetic achievement on the factor scores was also carried out. The results indicated that the arithmetic achievement was predicted by two common factors, 'Numerical Facility' and 'Visualization of Numerical Patterns'. The total variance in the scores of arithmetic achievement which was explained by the combination of these two factors was 8.10 per cent. 11. The results obtained by the process of multiple regression analysis of algebraic achievement on the factor-scores indicated that the algebraic achievement was predicted by the two common factors, namely 'Numerical Reasoning' and 'Numerical Facility'. The total variance in the scores of algebraic achievement which was explained by the combination of these two factors was 14.49 per cent. 12. The multiple regression analysis of achievement scores in geometry on the factor scores showed that only one factor, namely 'Numerical Reasoning', predicated achievement in geometry. The total accountable variance in the scores of geometrical achievement which was explained by that factor was 4.93 per cent. 13. The multiple regression analysis of the combined Achievement Test in Mathematics on the factor-scores of the Numerical Aptitude Test showed that only two factors, namely 'Numerical Reasoning' and 'Numerical Facility', were found to be the best predictors of achievement in mathematics. The total variance in the scores of achievement in mathematics which was explained by the combination of these two factors was 14.51 per cent.

***793.** DUTTA, A., *Learning Disabilities in the Reasoning Power of the Students in Geometry-Diagnosis and Prevention*, Ph.D. Edu., Kal. U., 1986

The main purposes of the study were (i) to diagnose the major patterns of disabilities in a specific area of geometry with the help of tools specially developed for the purpose, and (ii) to try out experimentally teaching methods which would prevent development of learning disabilities in the area under study. Three hypotheses were examined.

The study had two dimensions. The first was diagnosis of patterns of disabilities of students in the concepts of 'congruency of triangles' in geometry. The second part consisted of preventive measures adopted by the experimenter to check development of learning disabilities in this area with the help of audio-visual methods and techniques. A diagnostic test in 'congruency of triangles' was constructed to identify patterns of disabilities, and was administered on 286 slow learners in geometry. Structured individual interviews were conducted with 20 per cent students selected randomly from the original sample. In the second phase, the ex-

periment was conducted in four secondary schools with controlled and experimental groups. The initial measures by the verbal creativity test and criterion measures by the diagnostic test in geometry were subjected to analysis of covariance.

Some of the findings were: 1. Thirty-three major patterns of disabilities were identified. 2. The experimental groups taught by audio-visual materials and techniques achieved significantly more than the controlled groups taught by conventional methods.

794. KAUR, S., *Abstract Concepts in Different Areas of Mathematics—A Factorial Study,* Ph.D. Edu., Jammu U., 1985

The aims of the study were (i) to study the distribution of the abstract concept scores of three levels of education in the five areas of mathematics, viz. arithmetic, algebra, geometry, trigonometry and geometric form perception, (ii) to identify the difficulties in the study of mathematics areawise for the three groups, and (iii) to study the dominant factors of mathematics concepts at three levels of education.

Five tests were prepared, standardized and administered to 1200 randomly selected students, 400 for each group, namely Matric, T.D.C.(I) (Third Year Degree Course Part 1) and B.Sc. (Final). The composite reliability coefficient of the Abstract Concept Test in Mathematics (ACTM) was estimated by applying the Mosier Formula which came to be 0.94. The construct validity was estimated for all the five areas of ACTM.

The major findings of the study were: 1. The distribution of scores at the three levels of ACTM deviated from normality. 2. The scores in five areas of ACTM were positively skewed and platykurtic at matric level. The distribution of scores in all five areas was negatively skewed and platykurtic at T.D.C.(I) level, and at B.Sc. (Final) level the distribution was negatively skewed and leptokurtic except in the case of arithmetic where it was platykurtic. 3. The contrasted group analysis revealed that the students belonging to the B.Sc. class excelled in all the five areas of ACTM over the other groups. 4. The inter-correlated study of the five areas at three levels of ACTM showed that arithmatic, algebra and geometry were prominent and interdependent areas of mathematics. 5. The results of factor analysis revealed the following: (a) In case of matric students, the highest first factor loadings came against geometric form perception and trigonometry, whereas the highest second factor loadings came against the areas of arithmetic and algebra. These first and second factor loadings were called 'Figure Angular Factor' and 'Numerical Facility Factor' respectively. (b) In case of T.D.C.(I) students, the highest first order factor loadings came against geometric form perception and trigonometry and the highest second factor loadings came against algebra and arithmetic. These two factors were named 'Symbolic Number Ability' and 'Figure Angular Factor' respectively. (c) In case of B.Sc.(Final) students, the first highest factor loading came against trigonometry and geometry whereas the second highest factor loading appeared against arithmetic and algebra. These two factors were named 'Triangular Figural Relation Ability Factor' and 'Numerical Facility Factor' respectively.

795. KOLHE, S.P., *Construction of Attitude Scales and Measurement of Attitudes of Students of Jalgaon District towards Mathematics,* Ph.D., Edu., Poona U., 1985

The main objective of the study was to find out the influence of sex and urban-rural location on the attitudes of students of class X towards algebra, geometry and mathematics as a whole.

The sample comprised 2000 grade X students from urban and rural secondary schools of Jalgaon district of Maharashtra State. The boys and girls were 1000 each. The tools used to collect data were three Likert-type attitude scales developed by the investigator—one scale for attitude towards algebra, a second for attitude towards geometry, and a third scale for attitude towards mathematics. The reliability of the scales as determined by the split-half method using the Spearman-Brown Formula was 0.87, 0.91, 0.90 for algebra, geometry and mathematics attitudes scales respectively; t-test was used to examine the various null hypotheses formulated on the basis of objectives.

The major findings of the study were: 1. The students had favourable attitudes towards algebra, geometry and mathematics as a whole. 2. There were significant differences between the attitudes of urban and rural students towards mathematics and algebra, irrespective of the sex. Urban students had more favourable attitudes than rural students. (3) Urban boys had more favourable attitudes towards mathematics as a whole than rural boys. 4. There were no significant differences between the attitudes of urban girls and rural girls regarding algebra and geometry. 5. There were significant differences

between the attitudes of urban boys and urban girls towards mathematics as a whole, algebra and geometry. Urban boys had more favourable attitudes than urban girls. 6. There were significant differences between the attitudes of rural boys and rural girls towards mathematics as a whole, algebra and geometry. Rural boys had more favourable attitudes than rural girls. 7. There were significant differences between the attitudes of boys and girls. Boys had more favourable attitudes towards mathematics as a whole, algebra and geometry than girls, irrespective of the area they lived in.

The major implications are that teachers of urban and rural schools should be trained to develop favourable attitudes towards mathematics. The attitudes of urban and rural children—boys and girls, need to be improved. This can be achieved only by making teaching of the subject more interesting.

796. KRISHNA KUMARI, et al., *An Investigation into the Use of Mathematics Textbook (Class II) as a Tool of Teaching*, SCERT, Haryana, 1980

The objectives of the study were (i) to find out how far the teachers were conversant with the content given in the textbook of mathematics (class II) and taught this content to their students, (ii) to verify if the teachers taught mathematics in class II according to the approach given in the textbook, (iii) to find out to what extent the teachers followed the old and traditional methods other than those suggested in the textbook for teaching mathematics, and (iv) to find out whether the teachers had gone through the textbook themselves and whether the teachers actually felt the necessity of the textbook as an essential tool of teaching.

Sampling was done at two stages. At the first stage 33 primary sections were selected from primary/middle/high schools of Gurgaon District and at the second stage 771 students (315 girls and 456 boys) were selected for the study. Three tools were developed and used, viz. first, a questionnaire for checking the methodology and aids used by the teachers while teaching; second, an interview schedule for confirming the validity of responses of the questionnaire; and third, written/oral tests for the students for assessing their achievements. Chi-square values were calculated to test the hypotheses.

The main findings were: 1. Thirty-six per cent of the teachers did not at all look into the methodology provided in the textbook; rather they continued with the old pattern of teaching methods and did not even study the change in the syllabus. 2. Forty-nine per cent of the teachers made partial use of the methodology suggested in the textbook. 3. Fifteen per cent of the teachers studied the textbook thoroughly and tried their best to assimilate the new concepts and methods.

797. MAINKA, G.K., *Acquisition of Concept in Mathematics of Pupils at Primary School Level, and its relation to Some Personal and Environmental Variables of the Pupils*, Ph.D. Edu., Bom. U., 1983

The objectives of the study were (i) to determine if the ability to acquire mathematical concepts was normally distributed, (ii) to evaluate understanding and the acquisition of mathematical concepts of pupils, (iii) to determine the development level of mathematical concepts in each pupil which might facilitate the adaptation of material and instructional procedures according to the individual needs and the abilities of the pupils, (iv) to determine the development of mathematical concepts according to grades, (v) to determine the sexwise level of acquisition of mathematical concepts at each grade level, and (vi) to suggest better methods for later learning by securing more efficient learning methods for children in the acquisition of mathematical concepts.

The data were collected from 524 pupils from municipal schools, grant-in-aid schools, and private schools of urban areas from grade I through grade V. The pupils comprised both sexes varying from five years of age to 12 years of age. Tools employed in this study were Raven's Coloured Progressive Matrices Test, Abstraction and Generalization Test, Black Test, and Mathematical Concept Test. All the tools used in this study were specially constructed for this study except the Coloured Progressive Matrices Test. Different statistical techniques applied at different parts of the investigation were analysis of variance, t-test and correlations.

The study revealed that: 1. Gradewise sequential placement of concepts in the syllabus was not justified. 2. Scores of pupils in each concept showed consistent rise with increasing education level, revealing the existence of gradewise differences in the acquisition of set, number and space concept at primary school level. 3. The majority of pupils who were promoted to the next grade did not show acquisition of concepts of the lower grade. 4. A pupil did not acquire any concept to its fullest form in one grade but the growth of mathematical

concepts took place at all levels with different degrees of individual differences among the acquisition of mathematical concepts at primary school level. 5. With increasing age, a pupil made up in one or other concepts in mathematics, but his success in one concept was limited by the success in other concepts. 6. The highest variability in the acquisition of mathematical concepts was observed with pupils of grade III at primary school level. 7. Mathematical concepts developed better with pupils good in language and did not develop to their fullest form with pupils poor in language. 8. Concepts in higher mathematical hierarchy could not be developed unless the lower concepts were acquired. 9. There did not exist sex differences in the acquisition of mathematical concepts at primary school level. 10. For the better development and acquisition of mathematical concepts, individualized instruction was found useful. 11. Evaluation of concepts acquired in the unit test was difficult. True evaluation could be undertaken at the end of the year in the final examination.

798. MONDKAR, S.M., *Factor Analysis of Some Tests in Number Systems in the Mathematics Syllabus Prescribed from June 1972 for Std. VIII in the State of Maharashtra*, Ph.D. Edu., Bom. U., 1984

The objectives of the study were (i) to find factors underlying the ability required to learn number systems, (ii) to prepare tests based on these factors, and (iii) to analyse the tests factorially. The hypothesis of the study was: The ability to learn number systems is composed of three factors—General Intelligence (g), Number (N) and Perception (P).

The study was undertaken only in Marathi medium private secondary schools of Greater Bombay and of Thane City. A random sample of 400 students from nine schools was selected. In pilot testing 200 students, and for final testing, 400 students were selected. While selecting the sample for final testing, care was taken that a matching group from each school was selected on the basis of performance in mathematics in the first terminal examination. Tools employed in this study were eight tests in number systems, 'g' factor Scholastic Aptitude Test—Form A, and 'N' and 'P' factors tests suggested by Thurstone. The data were analysed by using Person's product moment correlation coefficient and Thurstone's Centroid Method of factor analysis. For testing sufficiency of factorization, standard error of Fisher's function and Tucker's empirical criterion were used.

The main conclusions of the study were: 1. The ability to learn number systems was chiefly composed of three factors, viz. General Intelligence (g), Number factor (N) and Perceptual factor (P). 2. In case of tests in number systems, boys showed higher performance than girls. 3. The locality factor did not affect the pupils' test performance in number systems. 4. The age factor did not affect the pupils' performance in tests based on number systems.

799. PATEL, N.R., *An Investigation into the Mathematical Ability of Pupils of Classes IX and X in the Context of Some Cognitive and Affective Variables*, Ph.D. Edu., SPU, 1984

The objectives of the study were (i) to provide a standard and valid tool to measure mathematical ability of pupils of classes IX and X, (ii) to establish norms of a mathematical ability test for classes IX and X, (iii) to study mathematical ability grade-wise, sex-wise and area-wise, (iv) to study mathematical ability in the context of some cognitive variables, viz. syllogistic reasoning and space visualization, and (v) to study mathematical ability in the context of some affective variables, viz. attitude towards mathematics and anxiety for mathematics.

The mathematical ability test was constructed by following the usual method of test construction. The test was standardized over a sample of 1250 students of class IX and 1035 students of class X. The reliability of the test by the test-retest method, split-half method and K.R. Formula-20, was found to be 0.91, 0.88 and 0.89 respectively. The concurrent validity was established by correlating the score on the test with teachers' opinion and was found to be 0.76. The predictive validity was established by correlating the score on the test with marks obtained in mathematics. The congruent validity was found to be 0.68. The percentile rank norms and T-score norms were established for urban and rural areas. The other tools used for collecting the necessary data were, (i) Space Visualization Test (SVT), (ii) Syllogistic Reasoning Test in Mathematics (SRTM), (iii) Mathematical Attitude Scale (MATS), and (iv) Mathematical Anxiety Scale (MANS). The reliability of the SVT was 0.90 and 0.95 by the split-half method and test-retest method respectively. The reliability of SRTM was 0.93 and 0.91 for classes IX and X respectively. The reliabili

ty of MATS by the test-retest and split-half method was 0.86 and 0.74 respectively. The reliability of MANS ranged between 0.84 and 0.89. The 2×2×2 factorial design was adopted to study the effect of cognitive and effective variables.

Some of the findings were: 1. The population under the testing programme was normally distributed and the curve was leptokurtic in nature. 2. There were no significant sex differences with regard to mathematical ability of pupils of classes IX and X. 3. There was a significant difference between mean scores of pupils of urban and rural areas, hence norms for these two areas were established separately. 4. The pupils possessing high reasoning ability were found to be better in mathematical ability than those with low reasoning ability. 5. The pupils having good space visualization were found better in mathematical ability than the pupils having poor space visualization. 6. The pupils possessing a favourable attitude towards mathematics were found better in mathematical ability than those with a less favourable attitude. 7. The pupils possessing high anxiety were inferior in mathematical ability to pupils having low anxiety. 8. The pupils of class IX having favourable attitudes were found superior to pupils of class X possessing unfavourable attitudes; hence the interaction effect between grade and attitude was significant, and the rest of the interactions were not significant.

800. RAO, A.V. RAGHAVENDRA, *An Investigation into the Relative Effectiveness of Guided Discovery and Expository Approaches of Teaching Mathematics*, Ph.D. Edu., And. U., 1986

The major objectives of the research were (i) to study the relative effectiveness of guided discovery and expository approaches of teaching mathematical concepts, (ii) to study the relative effectiveness of guided discovery and expository approaches of teaching problem solving, (iii) to study the interaction of intelligence and achievement in mathematics vis-a-vis guided discovery and expository approaches, and (iv) to study the relative effectiveness of guided discovery and expository approaches in different types of pupils, namely boys, girls and rural pupils. The hypotheses were: (1) There is no significant difference in achievement in mathematics among urban boys when taught by guided discovery and expository approaches. (2) There is no significant difference in achievement in mathematics among rural pupils when taught by guided discovery and expository method. (3) There is no significant difference in concept learning in mathematics among the above categories when taught by expository and guided discovery approaches. (4) There is no significant difference in problem solving ability among the above categories when taught by guided discovery and expository approaches. (5) Intelligence has no effect on achievement in mathematics when taught by guided discovery and expository approaches. (6) There is no significant difference in variability among the above categories of pupils when taught by guided discovery and expository approaches.

The population selected for testing the above hypotheses was class IX pupils of Vizagapattanam. From this population, three samples, namely, boys, girls and rural pupils, were selected. On each sample an intelligence test was administered. Each sample was then divided into two equivalent groups on the basis of their means and SDs on this intelligence test. Thus the two groups were matched for intelligence. After dividing each sample into two equivalent groups, one group was allotted to the guided discovery approach and the other was allotted to the expository approach. Identical topics from arithmetic, algebra and geometry were taught to both the groups for one month. After this a test on these topics was administered to the two groups. The randomized blocks design was based upon the principle of grouping experimental units into blocks. Blocks were formed on the basis of intelligence which was related to achievement in mathematics.

The major findings were: 1. There was no significant difference in achievement in mathematics when taught by the guided discovery and expository approaches. 2. There was no significant difference in achievement in mathematical concepts when taught by the guided discovery and expository approaches. 3. There was no significant difference in problem solving when taught by the guided discovery and expository approaches, except in the case of girls where a significant difference was found. 4. There was no significant difference in variance in achievement when taught by the guided discovery and expository approaches. 5. Intelligence had no say in achievement when taught by the guided discovery and expository approaches, except in the case of urban boys.

801. RAO, T.G., *A Comparative Study of Programmed Learning and Conventional Learning Methods in the Instruction of Mathematics—A Psychological Approach,* Ph.D. Edu., Osm. U., 1983

The objectives of the study were (i) to find out the efficiency of the programmed learning method over the conventional learning method in the instruction of mathematics in school education, (ii) to determine the variation in learning gains in the pupils in the rural-urban dimension, (iii) to determine whether there was any difference in learning due to sex variation of the pupils, (v) to investigate into the variations in achievement gains of the pupils in mathematics owing to variation in their general mental ability level under programmed learning instruction, and (vi) to find out the differential learning gains in the pupils owing to school climate, with special reference to private and government management of institutions.

The design was an experimental cum field investigation. Two matched groups of students were exposed to programmed learning and conventional classroom teaching. The subjects were matched on the rural-urban variable, sex, IQ, stage of instruction and management of schools. A sample of 300 students from grade V and 296 students from grade X was taken. Equal numbers of students were assigned to the programmed learning group and conventional learning group in both the grades. The tools employed for data collection were The Hyderabad State Bureau of Education Group Test of Intelligence (1980), an interview schedule to know the attitude of students, and achievement tests in mathematics for students of grades V and X.

The findings of the study were: 1. The mean performance scores of the programmed learning group and conventional group on the achievement test were less than the normative means of the tests. 2. The mean performance scores of all the programmed learning groups were higher than those of the corresponding conventional learning groups. 3. The performance of urban subjects was superior to the performance of the rural subjects under the programmed learning method, irrespective of grade. 4. The difference between the mean performance scores of the programmed learning and conventional learning groups was the highest in the case of urban subjects of grade X. 5. In grades V and X, girls scored higher than boys. 6. There existed no sex difference in the learning gains of the programmed learning groups separated on the basis of sex. 7. The mean performance scores of groups of subjects of high, average and low level of general mental ability were in the order of their categorization. 8. The significant differences were very high in the case of mean performance scores of the programmed learning and conventional learning groups of subjects in the category of high level of general mental ability. 9. Subjects of grade X gained more by the programmed learning method than subjects of grade V. 10. The increase in mean performance score of subjects of private schools was more by the programmed learning method of instruction as compared to that of government schools. 11. The difference between mean performance scores of the programmed learning and conventional groups was the highest in the case of the subjects of grade V of private schools. 12. The learning gains in mathematics were maximized by the programmed learning method in the case of subjects of urban private schools. 13. The girls of the private schools, irrespective of their stage of instruction, scored higher than the boys by the programmed learning method of instruction in mathematics, though these differences were not found to be significant. 14. Subjects of high general mental ability of private schools were the highest beneficiaries of the programmed learning method of instruction in mathematics.

802. RASTOGI, S., *Diagnosis of Weaknesses in Arithmetic as Related to the Basic Arithmetic Skills and Their Remedial Measures,* Ph.D. Edu., Gau. U., 1983

The objectives of the study were (i) to establish a relationship between achievement in mathematics and command over basic arithmetic skills, (ii) to establish a relationship between command over basic arithmetic skills and attitude towards mathematics, (iii) to establish a relationship between achievement in mathematics and attitude towards mathematics, (iv) to establish a relationship between general intelligence and the three attributes, viz. command over basic arithmetic skills, achievement in mathematics, and attitude towards mathematics, (v) to develop a diagnostic test to determine specific weaknesses of students backward in basic arithmetic skills, (vi) to develop a suitable programme for remedial work in basic arithmetic skills, and (vii) to investigate other causes of backwardness in mathematics and their treatment.

The design of the study was essentially experimental in nature. A test of basic skills in arithmetic and an attitude scale to measure attitude towards mathematics

were constructed and standardized. A diagnostic test of basic arithmetic skill was also constructed. Apart from these tools, Raven's Standard Progressive Matrices, a Mathematics Achievement Survey Test made by NCERT, and a course of self-help in basic arithmetic skills, which was a programme of remedial work developed to use as a treatment for the study, were used. The final sample included 406 class VIII students (230 boys and 176 girls) of nine different schools, one from each district of Arunachal Pradesh. In order to study sex differences and the effect of treatment on the two sexes, approximately equal numbers of boys and girls were included in the sample for the study.

The major findings were as follows: 1. One of the important causes of backwardness in mathematics was the poor command over basic arithmetic skills. 2. Attitudes were closely linked with achievement. 3. When command over basic arithmetic skills improved, attitude towards mathematics became more favourable and achievement in mathematics increased. 4. Basic arithmetic skills could very quickly and conveniently be mastered through the course of self-help in basic arithmetic skills as developed during the study. 5. There were no significant sex differences in either attitude towards mathematics or achievement in mathematics. 6. The course of self-help in basic arithmetic skills was equally effective with either sex.

The study provided a method and a few tools for combating stagnation, wastage and weakness in the subject. The method and tools were economical, convenient, time-saving, and did not require additional manpower or excessive demand on teachers' busy time schedule.

803. SASTRI, S.M., *A Study of Delay of Feedback and Retention in Rational Understanding in Mathematics*, Ph.D. Edu., And. U., 1984

The objectives of the research were (i) to study the effect of time gap on retentivity in learning of mathematics (T_1,T_2), and (ii) to study the effect of feedback on retentivity in the learning of mathematics (T_2,T_3). The hypotheses formulated were: 1. In respect of retentivity in the learning of mathematics, there is no difference between boys and girls in the age group 7-10½ years. 2. In the effect of feedback on retentivity in the learning of mathematics, there is no difference between boys and girls in the age group 7-10½ years.

The sample included 157 children out of which 86 were boys and 71 were girls. Of the above, 51 children (36 boys and 15 girls) belonged to standard V in the age group 9-10½ years; 45 children (20 boys and 25 girls) to standard IV in the age group 8-9½ years; and 61 children (30 boys and 31 girls) to standard III in the age group 7-8½ years. They were from an English medium public school. The variation in both the sexes in their retentive ability was examined. In order to see whether different kinds of test types were differentially affected by feedback, four types of test items were used, viz. questions requiring the subjects to reproduce factual information, questions on decimals to understand differences between decimal operation and normal numerals and algebraic operation, questions on arithmetic for testing understanding not only of the process of calculation but the usage in daily life, and questions on geometry for testing their understanding through the drawings of the geometrical figures. Three written tests on mathematics units taught by the researcher, were administered at different intervals, i.e. after the first test (T_1), the second test (T_2) was conducted on the same methodology after 40 days without any previous information, and after seven days of intensive drilling, they were tested again (T_3).

The major findings were: 1. The retentive capacity of the girls was more than that of the boys, in the following order, namely, decimals, arithmetic, numerals and geometry. 2. In arithmetic, both boys and girls did not show any interest during the period of feedback. 3. The girls possessed better understanding factors than boys in long-term retention. 4. The differences at the extremes, between very high scoring and very low scoring boys and girls were not so great as the difference over the middle range in students of standards III, IV and V. In the girls' median score, the change before and after the time gap was less than the change in the boys' median score before and after the time gap. 5. In memory ability there was a small but consistent sex difference, the girls being higher than the boys over the entire range in all the three standards, which contradicted the first hypothesis. 6. After feedback, the girls maintained their superiority over the boys, which contradicted the second hypothesis.

804. SINHA, B., *Construction of a Diagnostic Test of Arithmetic Vocabulary for Grades VI, VII and VIII, The Bureau of Educational and Psychological Research*, Govt. of West Bengal, Calcutta, 1971

The main aim of the study was to construct a diagnostic

test of Arithmetic Vocabulary for Grades VI, VII and VIII.

Consequent on an analysis of syllabi in arithmetic for classes VI, VII and VIII, the test was constructed with a view to detecting pupils' difficulties in the subject and to ascertain the nature, extent and causes of errors committed by them in respect of the concepts involved. The sample (N=214) was drawn from six schools in Calcutta.

Analysis of the backwardness levels revealed how some of the concepts got less importance in the curriculum of the class. Power of grasping the concepts and understanding the meaning of arithmetic terms were found to grow with maturation.

805. TIWARI, A.D., *An Investigation into the Interrelationship between Measures of Selected Guilford's S—I Factors and Set Concept Achievement of Secondary Level Students of Delhi State,* Ph.D. Edu., JMI, 1986

The objectives of the study were (i) to identify conceptual hierarchies of the set concept component in the secondary mathematics curriculum through content analysis according to the sequential learning model proposed by Gagne, (ii) to construct a set concept achievement test in order to assess achievement of class IX students, (iii) to identify the relationship between various reasoning ability tests involving cognition and convergent production of semantic classes, relations and implications of Guilford's Structure of Intellect model, (iv) to identify the relationship between various set concept achievement tests, (v) to identify the relationship between set concept achievement tests and reasoning ability tests, (vi) to identify the reasoning ability structure of class IX students studying in higher secondary schools of Delhi on the basis of reasoning ability tests, (vii) to identify constructs of set concepts in secondary school mathematics as measured by the six concept achievement tests, (viii) to identify factors common to the achievement of set concepts and reasoning abilities, and (ix) to identify the contributions of the reasoning ability tests to the variance in the achievement of set concepts.

In order to secure the measures of Guilford's S—I factors of cognition and convergent product of semantic classes, relations and implications, the Reasoning Ability Test Battery (19 tests) devised by Girish Bala (1978) was used. The investigator constructed Set Concept Achievement Tests (six tests) to measure achievement of the set concept in new mathematics. For the construction of the achievement tests, Gagne's (1965) model of concept hierarchy of capability-prerequisites was used to identify the model concept of 'set' and action verbs identified by Sullivan (1969) were used to specify test tasks for three levels corresponding to knowledge, understanding, and application of set concept learning. Two hundred and five boys of class IX constituted the sample for the study.

The findings of the study were: 1. Most of the reasoning ability tests had significant, low and positive correlations among themselves. 2. Intercorrelations among six set concept achievement tests ranged from 0.142 to 0.469. 3. Factor analysis of the intercorrelation matrix of 19 reasoning ability tests resulted in the identification of the factors—Inductive Reasoning or Cognition of Semantic Implications, Deductive Reasoning or Convergent Production and Convergent Production of Semantic Implications. 4. Factor analysis of the intercorrelations of six set concept achievement tests resulted in extraction of two factors—Ach. I-Concept of Set, and Ach. II-Concept of Function. 5. Correlations between reasoning ability tests and the composite of set concept achievement, except for Seeing Problem test, were all significant. 6. Factor analysis of the intercorrelation matrix of 19 reasoning ability tests together with composite set concept achievement shared significant loadings on deductive reasoning or convergent production or cognition of semantic implication factors. 7. Multiple regression analysis revealed that five tests, namely, Effects test, Figure Concept test, Association IV test, Syllogism III test, and Sequential Association test, contributed significant variance to the variance of composite set concept achievement. Three tests, namely Word Matrix test, Association IV test and Syllogism III test, contributed significant variance to the variance of the concept of set, and Word Classification test, Effect test and Figure Concept test contributed significantly to the variance of the achievement of the concept of function.

806. VAZ, V., *A Study of the Devices that can be used to Teach Modern Mathematics in Greater Bombay in Standards One to Ten,* Ph.D. Edu., Bom. U., 1982

The main objectives of the research were (i) to study the teaching of modern mathematics in schools, (ii) to make a survey of schools in Greater Bombay to find out the

devices that were used for teaching modern mathematics, (iii) to present a study of the uses of some of the principal devices to teach various topics of the syllabus, (iv) to design new devices where necessary and possible, especially devices that would meet the needs of schools in India, (v) to show how to incorporate activities into the course of normal teaching (vi) to set forth a plan of a modern mathematics workshop for the benefit of those schools which were in a position to have one, and (vii) to enable the teacher to handle modern mathematics in such a way as to make it a delightful and enriching experience for the students.

The extensive survey method was employed and purposive sampling was used for the selection of 100 schools. The data were collected by using a questionnaire and through an activity programme. The questionnaire was sent to 100 schools in Greater Bombay. Responses were received from 93 schools. An activity programme was conducted by the researcher. The programme touched all standards from I to X. Twenty seminars were conducted by the author in various parts of Bombay, Pune, Nagpur and the Nilgiris. At each seminar, participants prepared teaching aids. In the seminars each teacher submitted one project covering in detail a single topic in the syllabus or one particular type of aid. All the tools used in this study were constructed by the investigator. The data were analysed by using descriptive statistics.

The major outcomes of the study were: 1. The teachers developed a definite understanding of what modern mathematics was. It was the teaching of mathematics with meaning through a new approach, a new language, and a new content. 2. A knowledge of what was being done and what needed to be done by the teachers of modern mathematics in the schools of Greater Bombay was an important finding. A presentation of a vast array of manipulative aids for the teaching of mathematics, along with detailed instructions on how to construct and make use of them, was the final outcome. 3. The study provided a stimulus to teachers of mathematics to incorporate activities in their day-to-day teaching with the help of simple and readily available materials. 4. It developed skill among teachers to set up and organize a mathematics workshop. 5. Fifty-one of the 93 schools were not in a position to list even five aids that were commonly used by their teachers. 6. Sixteen schools were not able to mention even a single aid.

807. VYAS, C.S., *Development of Symbol Picture Logic Programme and to Study its Effect on Mathematics Achievement—A System Approach*, Ph.D. Edu., SPU, 1983

The objectives of the study were (i) to develop a symbol picture logic programme (SPLP) on the basis of the fundamentals of symbolic logic, (ii) to study the effectiveness of the SPLP on the achievement in mathematics, (iii) to identify the effect of the SPLP in the context of variables like intelligence and syllogistic reasoning ability, and (iv) to find the effectiveness of the SPLP in the context of other variables like parent education, sex and the choice of mathematics course at the S.S.C. level.

The symbol picture logic programme was developed keeping in mind the basic element of logic to be included in set programme and the basic connectives in logic. For selecting the basic connectives in symbol picture logic, the concept of Linda Jestrom of the Centre for Research in Thinking and Language of Catholic University was kept in mind. The equivalent group technique was adopted. There were 160 students in the experimental group and 160 in the control group. Four schools were selected at random from 16 schools of Bayad taluka. The other tool that was used for collecting data was the Group Test of Intelligence by K.G. Desai. The $2\times2\times2$ factorial design was adopted for studying the SPLP in relation to achievement, parents' education and sex. Analysis of variance technique was used for analysing the data. The experiment was carried out on students of class IX.

Some of the findings were: 1. The students of the experimental group who were given a treatment of the SPLP showed better achievement in mathematics than the control group students. 2. The students with high intelligence benefited more by the SPLP by better achievement in mathematics than those who possessed low intelligence. 3. The student possessing high reasoning ability benefited more by the SPLP by better achievement in mathematics than those who possessed low reasoning ability. 4. There was no interaction between the programme (treatment) and intelligence. 5. There was no interaction between the programme and syllogistic reasoning ability. 6. There was no interaction effect of intelligence and syllogistic reasoning ability of the students. 7. There was no interaction among the programme, intelligence and syllogistic reasoning ability. This showed that the achievement in mathematics was independent of these three variables. 8. The students of the control group possessing low general ability

and low syllogistic reasoning were inferior to the students of the rest of the group. 9. The students of the experimental group possessing high intelligence and high reasoning did better in achievement i.. mathematics than the students of the control group possessing low intelligence and low reasoning ability. 10. There was no significant mean difference in achievement in mathematics of students whose parents' education was high and those whose parents' education was low. 11. There was no interaction effect between the programme and parents' education. 12. The students choosing higher mathematics course did better in mathematics achievement after taking the SPLP than the students who chose commercial arithmetic. 13. There was no interaction between the programme and the choice of course. 14. There was no significant difference between the means of achievement in mathematics of boys and girls taking the SPLP, and also there was no significant difference between the means of achievement in mathematics of boys and girls who did not take the SPLP.

The study implied that the mathematics teacher could use the symbol picture logic programme in secondary schools to make students active participants in the thinking process, to cultivate the students' ability of logical thinking spontaneously, to motivate students to comprehend a symbolic strategy rather than rote learning of figurative rules, and to help students to visualize the explicit meanings of symbolic expression first and then to verbalize.

ALSO SEE

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