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A REVIEW ON CRITICAL STUDY OF EFFECTIVENESS OF PI AND CAI FOR MATHEMATICAL LEARNING DISABILITY STUDENTS

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ABSTRACT
In order to expand understanding and identify successful techniques or products for which there is already a prior knowledge base established by other researchers, one of the main goals of research is to produce information in this area. When planning, carrying out, interpreting, and reporting their research, researchers heavily rely on the professional literature. In approaching the literature, the researcher has several goals in mind. One of the goals of a literature review is to determine what research has previously been done, to spot any deficiencies or gaps in the body of existing knowledge, and to gather data necessary for interpreting the results. The construction of a theoretical or conceptual framework by the researcher is another goal of the literature review. A lot of books, dissertations, research papers, periodicals, journals etc. were consulted by the researcher as she gathered a substantial amount of research that was either directly or indirectly relevant to the subject at hand. This was done with the understanding of the value of reviewing related material. For ease of understanding, the examined researches were then divided into the categories that are detailed below.

Keywords: *Programmed Instruction, Computer Assisted Instruction, Mathematical Learning Disability*.

INTRODUCTION
From "womb" to "grave," education—a vital component of a good and enlightened life—is a constant and lifelong process. A person learns, feels, craves, and is given the opportunity to learn every year, every month, and every day. Nobody in the newly forming world knows what tomorrow will bring. And we need to provide every man the tools he needs to be the captain of his own destiny and master of his fate in every way and at every stage of his life. Education reflects the societal social structure. It aids in the advancement and growth of society, the state, and subsequently the country. It is for this reason that Diogenes asserted that "the cornerstone of every state is the education of its youth." Schools are thus a necessary component of society because they are the only institutions tasked with formally educating children. Assuming that people are capable of learning and paying attention to the presentation of knowledge, that they desire to learn, and that there is "a body of knowledge and skills to be taught," schools are established on the premise that people lack the general knowledge, morals, and intellect required for culture (Broudy, 1978).

RESEARCHES RELATED TO MATHEMATICAL LEARNING DISABILITY
Although the field of learning disability is a recent one, the researchers have been undertaken related to remediation of mathematical learning disability. The amount of research on teaching math has increased substantially in the last decade and it is now clear that both curriculum design and teacher behavior directly influence the mathematics achievement of students with learning problems (Kameenui and Simmons, 1990; Kelly et al., 1990; Mastropieri et al., 1991; Mercer and Miller, 1992; Hutchinson, 1993;Mercer, Jordan and Miller, 1994). The researches relevant for the present study have been reviewed below so as to provide insight into various attempts at remediation.

Lovitt and Curtiss (1968) evaluated the effects of requiring an elementary age boy identified as having behavior problems to read arithmetic problem aloud before writing his answers to them. The boy's performance improved on three types of arithmetic problems when this antecedent event was manipulated. However, the results were not reversible, as required by the experimental design used to assess these changes. Many studies have investigated procedures that have been recommended for inclusion in Cognitive-Behavior Modification (CBM) interventions with learning disability.

Parsons (1972) studied the effects on arithmetic accuracy of having pupils both circle and name the operation symbol before performing addition and subtraction computations. The positive effect of this tactic have been interpreted as support for the idea that antecedent self-verbalization is a desirable component of CBM programmes.

Smith and Lovitt (1976) demonstrated an important relationship between reinforcement and academic performance. In two studies, they assessed the arithmetic computation performance of 10 elementary-age boys (three in one study and seven in the other) identified as learning disabled. Their results indicated that reinforcement contingencies have little effect on rate or accuracy unless the pupils know how to perform the required operations. A similar finding was reported by another study by Grimm, Bijou and Parsons (1973).

Cullinan, Epstein and Lloyd (1978) repeated the study by Lovitt and Curtiss (1968) using boys identified as learning-disabled and using multiplication instead of subtraction problems but they didnot obtain similar results.

Joffe (1980) found that 61% of dyslexic children were not achieving in arithmetic at a level commensurate with their chronological age, despite average or above average intelligence.

Weinstein (1980) also refers to the fact that many researchers in the USA take for granted the factors of 'inadequate instruction, poor motivation or general mental retardation' when referring to low attainment in mathematics, but fail to look for cognitive factors.

Tansley and Penkhurst (1981) refer to the fall that some poor readers are also below average in mathematics but the precise nature of the association is not clear. They also claimed that there is insufficient existence whether 'poor arithmetic performance is associated with specific learning disabilities. 'Two particularly valuable studies of CBM have been conducted in the arithmetic area.

Johnston, Whitman and Johnson (1981) and Whitman and Johnston (1983) evaluated the effects of a self-instructional intervention for teaching arithmetic computation skills. In both the studies, pupils were taught algorithms for solving specific types of arithmetic problems. The results inferred that this intervention had clear and substantial effects on the students' performance.

Lloyd et al., 1981 reported the results of an intervention programme based in part on the DIM. In their study, learning disabled pupils received reading instruction that use of the Corrective Reading Programme and their reading scores were compared to the reading scores of a randomly assigned comparison group after six months of instruction. The pupils in the Direct Instruction groups had significantly higher scores on (a) word reading (as measured by the Wide Range Achievement Test), (b) passage reading (as measured by the Gilmore), (c) passage comprehension (as measured by the Gilmore). The authors reported that the effect sizes for these measures were 0.71 or greater.

Lloyd, Saltzman and Kauffman (1981) examined the effects of "strategy training", an instructional procedure based on the Direct Instruction Model principle of teaching cognitive operations by isolating and teaching a series of steps that lead to solution of a type of problem (Lloyd, 1980). The authors found that transfer of training was predictable on the basis of the instruction provided to learning-disabled pupils. The results were consistent with the findings of Carnine (1980) who reported that young non-handicapped pupils provided instruction on the component skills of a multiplication strategy had more rapid acquisition of the strategy and greater transfer of it to untrained items than did young non-handicapped pupils who were taught the component skills and the strategy at the same time.

Swanson (1981) examined the effects of self-recording and reinforcement techniques on the reading of elementary-age, learning-disabled pupils. In a series of three studies **(Swanson, 1981a)**, he found that self-recording and reinforcement contingencies influenced oral reading accuracy, silent reading rate, and comprehension question accuracy.

Cockcroft (1982) stated that "low attainment can occur in children whose general ability is not low", but the reason given for such retardation where 'inappropriate teaching, lack of confidence, lack of opportunity, frequent or prolonged illness and poor reading skills.' These factors may all be important, but there may also be underlying learning disabilities of a cognitive nature which need to be remedied.

Joffe (1983) brought a fact to our attention that specific mathematical disability is 'a disappointing feature' of the schools council working paper report.

Leon and Pepe (1983) used a self-instructional format to teach LD and educable mentally handicapped students. Their training programme contained the following elements: modeling, feedback, self-administration of reinforcement, coping instructions, and a self-instructional dialogue. Children in the self-instruction condition outperformed their control group peers on both post test and generalization measures.

Miles (1983) found in the study of dyslexic children aged 7-18 years that many dyslexia children were inaccurate on items such as subtraction, knowledge of tables and reciting months of the year. He found that among the 80 children in the age group of 9-12 years,58% scored significantly more errors in subtraction, 96% scored significantly more errors in knowledge of tables and 60% scored significantly more errors in reciting the months of the year, than average readers.

Torgesen and Young (1983) argued that the reading problems of many learning disabled students are exacerbated by their inability to recognize isolated words.

Gelzheiser (1984) concluded that the extensiveness of specifics strategy knowledge does not appear to be a major determinant of generalization with LD children. a similar conclusion, that extensive training of strategy use is necessary but not sufficient, for strategy generalization has been reached by Borkowski and Cavanaugh(1979).

Gerstene*t al.* (1984) examined the relationship between children's IQ at the beginning of schooling and their yearly academic growth under the Direct Instruction Model. They found that pupils with low IQs (i.e., those with IQs<71) achieved at essentially the same rate as their peers with higher IQs (i.e., those with IQs between71 and 90 and those with IQs>90) during the first two years of schooling, but that at the third grade level the students with low IQs experienced significantly slower progress in reading in comparison with their peers. Of particular interest here is that the students who would traditionally be called "slow learners" or might have been classified as learning disabled (i.e. those in the IQ 71-90 group) acquired basic skills at about the same relative rate as their more capable peers, given instruction based on the Direct Instruction Model.

Lombardo and Drabman (1985) used the 'write and say procedure' in multiplication problems. In the first phase, they did not practice the works in any particular way. In the second phase, they wrote answers to problems on their practice sheets. During third phase, pupils wrote answers to their problems and also verbalized the problems and answers. Findings signify that performance of only a few was affected by the write only condition, nearly all students were positively charged by the write and say procedure.

Swanson and Rhine (1985) compared strategy transformations in mathematics of learning disabled and non learning disabled students (mean age 13). The two groups did not differ in terms of computation but differed in the use of strategies to access information and apply it. Non learning disabled children handled information at a higher rate, spend more time considering an alternative method grouping mental operations and less time recalling computational knowledge than the learning disabled children.

Leonora Harding (1986) wrote a book "Learning disabilities in the primary classroom" referring the studies conducted by Kose (1974), Badian (1983). From this it would appear that whereas 6.4%of school children have a disability in mathematics, only 3.7% of children have a disability in mathematics alone, the remaining 2.7%having a disability in both mathematics and reading. However, neither of these studies gave precise information about the level of backwardness and the test used is often not standardized so that incidence figures must be taken as rough estimates only.

Englert, Culatta and Horn (1987) gave pupils (learning disabled and non learning disabled) a number of addition word problems with irrelevant linguistic numerical information embedded within them. Results indicated that regular class students revealed greater accuracy and speed in solving the problems than their learning disabled peers. Learning disabled students experienced more difficulty in solving problems containing irrelevant numbers than non-learning disabled students.

Larson *et al.* (1987) indirectly tested the hypothesis that the social skill deficits of learning disabled students may be related to cognitive processing rather than to general social skills deficits

(Hazel*et.al.,* 1982) in a social skills training program. In this study, the effects of metacognitive training on negative behavior were test educing 34 learning disabled and 34 low-achieving incarcerated 16 to19 year old delinquents. Subjects were randomly assigned to metacognitive training or an attention or a test only control group. Following training, subjects were tested on metacognitive awareness of self and others. The results found that LD and NLD subjects in the metacognitive condition were significantly better than LD and NLD subjects in the two control conditions in identifying meta-other and meta-self variables. On meta-control knowledge, the LD subjects identified more metacognitive control steps than LD subjects in the two control groups. Changes in behavior were reported by staff at the institutions. The LD and NLD treatment groups were rate higher on reducing negative behavior than subjects in the control groups.

Lenz *et al.* (1987), the investigators matched regular classroom content teachers with and individual, who already in their class were identified as having a learning disability. Components associated with organizer use (beginning of a lesson, during a lesson, and after a lesson) were identified and the teachers were observed over a period of a days to determine how they typically used organizers. Measures of students-learning were also obtained. Teachers were trained to use advance organizers and their implementation of the teacher-constructed advance organizers were than observed. While teachers implemented the teaching routines, very little change was observed on the measures of student learning. Students were then informed of the presence of the advance organizer and were prompted to take notes and begin to use the advance organizer to organize learning. Improvement on the student measures was then observed. A key factor in the success of this routine was the student's awareness of the routine and the knowledge of how it could be used to facilitate learning. Applying the theory of information processing to the problems that learning disabled children face in Mathematics.

Pellegrino and Goldman (1987) found that these students have difficulty in both processing the knowledge of the number facts and 'formulating the rules' of Mathematics. Research about the application of the Direct Instruction Model with learning disabled children has been extensive and has been reviewed by many researchers. In such a review of much of the same literature, **White (1987)** reported a meta-analysis of 25 studies. He found an average effect size of 0.81 for academic measures indicating that pupils receiving Direct Instruction were far better served than those in control or comparison conditions.

Hale *et al.* (1988) was to observe whether enriched instructions during strategy acquisition would be sufficient to alleviate strategy transfer deficits commonly found with LD children. To overcome this deficit, LD children were provided with extensive feedback about strategy utility, as well as direct practice using strategies in different learning situations. It was assumed that feedback and practice would be sufficient to enhance their understanding of a strategy's appropriateness and would lead directly to its successful generalization. In the study, the performance of elementary school-aged learning disabled children, who were at least two years behind in their reading achievement scores, was contrasted across three conditions: traditional strategy training, enriched strategy training and a non-instructional control. Children in the two strategy conditions were trained to use two dissimilar strategies, categorization and method of loci. Children received two generalization tests, one for near-generalization and another for far-generalization. Results of the study indicated significant differences between the strategy trained groups and the control condition on strategy use and recall for both the near and far generalization tests of categorization, and recall on the far generalization task for method of loci. No reliable differences were found between the two strategy training groups on measures of recall or strategy use.

Kirby & Becker (1988) studied cognitive components of learning problems in arithmetic. The purpose of the study was to observe those components in children who differ in arithmetic proficiency, and to determine which are associated with arithmetic problems. The literature review has supported the hypothesis that one or more of encoding strategy and operation execution process may be at fault. Three groups of grade 5 children were used to test these hypotheses. A sample of 48 subjects was selected from a pool of 200 (10 and 11 year old) children in general classrooms. The three groups were, a group with arithmetic problems (Ap), a group with reading problems (Rp), and a control group (C). Selection was based upon performance on test of intelligence, reading comprehension and

arithmetic. The results of the study provide little or no support for the encoding and strategy factors, but to show that children with learning problems in arithmetic have poor operational efficiency. The study demonstrates that children with learning problems in arithmetic lack automaticity in the basic arithmetic operations and suggest that they may not carry out the actual operations with the optimal algorithms (strategies). This study leads us to conclude that other more narrow causes need to be explored, many of which could be quite specific to the subject matter being learnt.

Sachse-lee (1988) studied the relationship between working memory and mathematical problem solving in children with and without learning disabilities. The purpose of the study was to find whether individual differences in verbal and visual-spatial working memory (WM) contribute to the problem solving performance of5th and 6th grade children with LD. Another goal was to determine whether WM is predictive of problem solving scores after the influence of basic skills and/or lower order cognitive processes are partial out. To address these issues, the relationship between the WM skills and mathematical problem solving performance of students with and without learning disabilities was analyzed. A reading level design was employed where in 31 fifth and sixth grade students with learning disabilities (LD), 47 fifth and sixth grade students without learning disabilities (CA), and 30 reading level control students without learning disabilities (RL) were assessed on WM and word problem solving tasks. Correlation and Multivariate approaches were used to analyze the data. Significant ability group differences emerged on all measures. LD children were inferior to age-matched controls, but their performance was significantly comparable to that of reading level controls on most measures. Significant co-relations were obtained between problem solution accuracy and WM in children without LD, but not in children with LD. Finally, scores from WM tasks were predictive of problem solving performance for the combined sample after the influence of academic skill and after cognitive processes were partial out. Both verbal and visual spatial WM were predictive of problem solution accuracy in the RL group, butonly visual spatial WM explained the performance of subjects in the CA group. Neither verbal nor visual-spatial WM were predictive of problem solution accuracy for LD subjects.

Lazar *et al.* (1989) studied math's, reading and language arts teachers in Kindergarten through eighth grade. Their findings revealed that 36% of all teachers' utterances contained at least one multiple meaning expression. Indirect requests (27%) occurred most frequently. Moreover, at least one idiom in 12% of the utterances, and more idiomatic expressions were used as grade level increased. Thus older students with language problems may become increasingly unable to follow teacher directions or understand classroom discourse.

Cawley*et al.* (1992) explored the arithmetic problem solving abilities of learning disabled students in secondary schools. Problems differing on two sets of characteristics were given; direct/indirect or extraneous/non-extraneous. In direct problems, wording was consistent with the operation to be followed indirect problems the wordings and the operation were not in agreement. Some problems contained extraneous information others did not. Data revealed that indirect problems and problems with extraneous information tended to be more difficult for learning disabled children than direct problems and ones without extraneous information.

Harris & Graham (1992) studied improving the mathematical problem solving skills of students with learning disabilities: Self-regulated strategy development. The purpose of the study was to examine the effectiveness of a strategy for solving simple addition, subtraction word problems. The participants were fifth - and –sixth grade students with LD receiving self-contained classroom services in a large metropolitan city in the northwestern United States. The problem solving strategy was taught using the self-regulated (self-assessment, self-recording, self-correction) strategy development procedures. Instruction emphasized the student's role as an active collaborator and included principles of interaction scaffolding and Socratic dialogue. The effects of the strategy and accompanying instructional procedures on the participating student's performance in solving word problems was assessed through the use of a multiple- baseline - across subjects, across two behaviors design. Upon completion of instruction, student's overall performance on mixed sets of addition and subtraction word problems improved and they were less likely to perform the wrong operation. The results of the current study, therefore, are congruent with the previous investigations showing that strategy

instruction is effective for addressing important mathematical difficulties exhibited by students with learning disabilities (Leon &Pepe, 1983; Montague &Bos, 1986).

Baker (1993) investigated the effect of self-generated drawings on the ability of students with learning disabilities to solve mathematical word problems. The purpose of the investigation was to determine the effect of student-generated drawings on the ability of students with learning disabilities to solve two types of mathematical word problems. Forty-six, third, fourth and fifth grade students previously identified as learning disabled participated in this study. The students were randomly assigned to a control group or an experimental group. The control group received instruction in the use of a four-step word problem solving strategy, which included reading the problem, restating the problem information, identifying the unknown information, and generating a problem solution. The experimental group received instruction in the same four-step strategy but in addition, was encouraged to draw a picture representation of the problem information before solving the problem. Both the experimental group and the control group practiced solving two types of change problems, one involving multiplication or repeated addition and the other involving division or repeated subtraction. A pretest post-test measure was used to evaluate changes in the problem solving skills of the two groups. Statistical analysis revealed no significant differences between the experimental and control groups on the posttest measure for either of the two problem types. Both groups demonstrated an increase in mean raw scores from the pretest to the posttest. A content analysis of the experimental subjects drawing on the posttest revealed that the students produced a variety of picture representations for mathematical word problems.

Whinnery (1993) investigated the effects of training students with learning disabilities to use two cognitive strategies (i.e., goal and test-taking) to improve math computation skills. Participants were 40 students with learning disabilities and their 24 teachers who had volunteered for a 20 week Curriculum-Based Measurement (CBM) study. Teachers were randomly assigned goal or no goal conditions. Each teacher selected two students to participate; one was assigned randomly to test taking and the other to no test taking strategies training. The resulting four treatment conditions were: goal/test-taking strategy (n=8), goal/no test-taking strategy (n=10),no goal/test-taking strategies (n=11) and no goal/no test taking strategy (n=11). During week 4, students in the test-taking strategy condition were trained to use a math test-taking plan when preparing for and taking the twice-weekly tests. During week 5, students in the goal condition were trained to identify and strive for specific goals for their twice-weekly CBM tests. The training effects were assessed on three different outcome measures: (a) math performance characteristics, (b) math achievement, and (c) math self-efficacy. Analysis of variance did not indicate an effect for goal strategy training on any of the three outcome measures. However, a test taking strategy's main effect was shown for math's achievement. Students with test-taking strategy training scored higher on a math computation test than students with no test-taking strategy training. These findings are discussed in the context of implications for classroom instruction and future directions for research.

Behrend's (1994) study examined the problem-solving processes of five second and third grade students identified as learning disabled. Cognitively guided instruction (Fennema and Carpenter, 1985) provided the framework for assessing the children's independent and assisted problem solving abilities. Data was gathered during individual interviews and small group sessions. Behrend found that all the five students could solve a variety of problems including difficult addition, subtraction, multiplication, and division word problems: problems with extraneous numerical information; and multiple step problems. The study recommended instructional approaches that utilize student's available problem-solving processes.

Lemai tree (1995) investigated mathematical comprehension of adults with learning difficulties. In order to better understand the mathematical comprehension of adults having difficulties in mathematics, five students were asked to 'think aloud' as they worked through fifty-two fraction questions during four or five 'math sessions' over several weeks. For the purpose of this study one of the students' results was examined in greater detail. Emphasis was given to the first sixteen questions, which consisted of equal combinations of addition, subtraction, proper, and improper fractions, each with like and unlike denominators. The remaining questions and other students' results were used to

supplement this material. Data was also gathered from (i) an initial interview, including a short questionnaire; (ii) the Woodcock-Johnson Psycho-Educational Battery (WJPEB) (Woodcock& Johnson, 1978); (iii) Raven's Standard Progressive Matrices (Raven, 1960); (iv) Documented material; and (v) Classroom observations. Results from a pilot study were also reported and discussed.

The outcome indicated a number of similarities in the difficulties demonstrated by these adults and those manifested by children. Many related to aspects of mathematics such as the students' lack of actual knowledge, attention and organizational ability. However, unlike their younger counterparts, the errors made by these adults could not be attributed to a lack of time or memory or cognitive development.

Montani (1995) studied calculation skills of third grade children with mathematics and reading difficulties. The study examined calculation performance of children with (1) difficulties in mathematics but not reading (Low Math); (2) difficulties in both reading and mathematics (Delayed); (3) difficulties in reading but not mathematics (Low Reading); and (4) no academic difficulties (Control). Calculation performance was assessed on both story problems and number-fact problems under timed and untimed conditions.

Wang (1997) investigated the effectiveness of computer based self-instruction training programme (CBST) for teaching Math problems to children with learning disabilities. Six children, ranging in age from 7 to 11, participated in the study. The students were enrolled in a special education programme in an elementary school in Taipei, Taiwan. A multiple baseline probe design across subjects was used to analyze the effects of CBST. The self-instruction training procedure was based on Meichenbaum and Goodman's five-step training probe type (1971) with minor modifications. In the present study, the computer programme functioned as the instructor through written and oral prompts. The experimental procedure comprised of four phases: baseline, intervention, maintenance, and follow up. Two dependent variables, the percentage of problems completed correctly and the duration of time for task performance, were recorded for all students using computer-based tests. Two types of concurrent generalization measures were employed to evaluate the effect of transferring the performance of problem solving from horizontal to vertical format questions and from computer based tasks to paper-pencil work sheets. Following a variety of five to eight training sessions during the intervention phase, students demonstrated the competence to solve arithmetic problems at a high level of accuracy. The performance of problem-solving on the computer also generalized to the questions in paper-pencil tests and to vertical format of the tests. The results of this study support their research on the efficacy of self-instruction and computer based instruction. It did not evidently support that the students were able to automatically respond to the questions when they were engaged in a missing added problem. Recommendations for future research included suggestions for using of CBST (a) with students with other disabilities (b) in other geographical areas and(c) in the subject other than math.

Ediger, M. (2002) found that calculators, computers with accompanying software pertaining to tutorials, analysis and remediation, drill and practice games and simulations are good to use as manipulative in hands on mathematics learning.

Jiménez *et al.* (2003) assessed whether the effects of computer assisted practice on visual word recognition differed for children with reading disabilities (RD) with or without aptitude-achievement discrepancy. A sample of 73 Spanish children with low reading performance was selected using the discrepancy method, based on a standard score comparison (i.e. the difference between IQ and achievement standard scores). The sample was classified into three groups: (1) a group of 14 children with dyslexia (age M=103.85months, SD=8.45) who received computer-based reading practice;(2) a group of 31 "garden-variety" (GV) poor readers (age M=1-7.06 months; SD=6.75) who received the same type of instruction; and (3) a group of 28 children with low reading performance (age M=103.33 months; SD=9.04) who did not receive computer-assisted practice. Children were pre- and post-tested in word recognition, reading comprehension, phonological awareness, and visual and phonological tasks. The results indicated that both computer-assisted intervention groups showed improved word recognition compared to the control group. Nevertheless, children with dyslexia had more difficulties than GV poor readers during computer-based word reading under conditions that required extensive phonological computation, because their performance was more affected by low-frequency words and

long words. In conclusion, the study not found any empirical evidence in favor of the IQ-achievement discrepancy definition of reading disability, because IQ did not differentially predict treatment outcomes.

SUMMARY

An analysis of the researches reviewed and reported above reveals the following:

1. Very few researches have been undertaken in India as far as the area of mathematical learning disability is concerned.
2. A handful of researches on effectiveness of CAI and PI have been taken up but only for normal children.
3. Researches on intervention with learning disability have been very less in number, have lacked adequate research-design and have not been properly conceptualized.
4. No research was found to deal with effectiveness of CAI and PI as a whole for learning disabled children.
5. Consistency and conscience in the matters of identification of learning disability are non-existent in present situation.

Thus, it can be safely assumed that the present study to assess effectiveness of PI and CAI for children with mathematical learning disability will be of foundation-value as well as a milestone in future of research in India, at least with learning disabled children.

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