Acquisition of Concept of Conservation of Length in Elementary School Children through Piagetian Teaching Model

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Abstract

The purpose of the present study was to examine the effect of training programme based on Piaget's theory on the elementary school children's acquisition of the concept of conservation of length. The experiment involved the use of pre-post-delayed post test design. 40 children were selected for the study out of which 24 constituted the experimental group and 7 children were assigned to the control group on the basis of their pre-test performance. Nine children were not included in the experiment because they have successfully completed the length conservation tasks during the pre-test. Results indicated more than 40 per cent progress immediately after the training but got raised to more than 50 per cent progress at the second post-test. The major implication of the study is on the designing and development of appropriate teaching learning strategy for primary school children.

Introduction

In India, there has been a sizable quantitative improvement in education since independence. However, as far as qualitative improvement is concerned the situation is a dismal one. The learning programmes and the teaching strategies adopted by our school fail to bring out all round development of children. Concepts are taught to students in theoretical way and not by experimentation.

Various efforts have been initiated to improve the quality of education system in India. The Education Commission (1964-66) stressed the need to pay a greater attention in bringing about qualitative change in the method of teaching. The report recommended that in the lower primary classes teaching should be related to child's environment and at the higher primary stage emphasis should be laid on the acquisition of knowledge, the ability to think logically, and draw conclusions

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and to arrive at scientifically tenable decisions. The method should be modernised stressing on the investigatory approach and the understanding of basic principles.

The National Policy on Education (1986), which is an action-oriented document, laid special stress on the development of proper education programmes for young children. The report made it clear that the new thrust in the elementary education should emphasise a substantial improvement in the quality of education so as to enable children to develop themselves by exercising their own initiative, their own personality, learning abilities and communicating capabilities. Various educational systems and programmes suggested over the years have focussed on active participation of children in the construction of knowledge but they were not based on any sound empirical foundation. However, current view on cognitive development has been greatly influenced by the pioneering work of the Swiss Psychologist Jean Piaget. Piaget is of the opinion that knowledge is constructed by the child through its active transaction with the environment. Certainly the scientific knowledge about the development of children's cognitive abilities—how children think and how that thinking systematically matures over time could be useful in making decisions about teaching strategy and designing of the curricula.

Purpose

The purpose of this study was to examine the effect of training programme labelled "From Elementary Number Conservation to the Conservation of Length" based on Piagetian approach on the primary school children's acquisition of the concept of conservation of length. More specifically, the investigator attempted to find answer to the following questions:

1. To what extent do selected training programme affect the primary scool children's concept of conservation of length?
2. Does any difference exist in concept of conservation of length between children who have had participated in training programme and the children who have not had participated in such training programme.
3. What are the mechanisms of transition involved in progress from one stage to the next stage marking the development of concept of conservation of length.

Methodology

Design of the study: The experimental programme involved the use of pre-post-delayed post-test design.

Sample: The subjects were 40 children (20 girls and 20 boys) randomly selected from second grade of Rani Laxmibai Memorial School, Indira Nagar, Lucknow. Their age ranged from 5:0 years to 7:4* years.

General Design: The experiment consisted of three phases: pretesting, training and two-stage posttesting. In the pretesting subjects were given the Conservation of Number and Conservation of Length. 31 subjects who

* the child is 7 years 4 months old

have successfully completed the elementary number conservation problems and unsuccessful in conservation of length task were selected for the expriment. 9 children of ages 5:0 yrs. to 7:3 yrs. were not included in the experiment because they successfully completed the conservation of length tasks during the pre-test. Out of 31 subjects , 24 ranging in age from 5:5 yrs. to 7:4 yrs. constituted the experimental group while 7 subjects of ages 5:1 yrs. to 7:1 yrs. were assigned to control group.

Training programme: 24 subjects of the experimental group took part in three training sessions administered twice a week, each lasting 15 to 20 minutes.

The child was always asked to build a road "of the same length as" or "just as long as" the model, or to build his road "so that there is no further to walk on it than on the other".

In all the situations of Session 1, matchsticks were used, those given to the child being shorter than those used in the model (exact proportion 5:7).

In the situation of complex close layout (see Figure-1) the child had to build a straight road of the same length as the zigzag model road. The general layout of this model was such that the most obvious solution was to make the end points coincide.

Furthermore, as the child's matchsticks were shorter than those in the model (four short matchsticks placed in his straight road "go just as far" as the five long ones of the zigzag model), counting alone could not result in the correct answer although it could help the child overcome the tendency to concentrate on the end points. The correct answer could be derived from situation (iii).

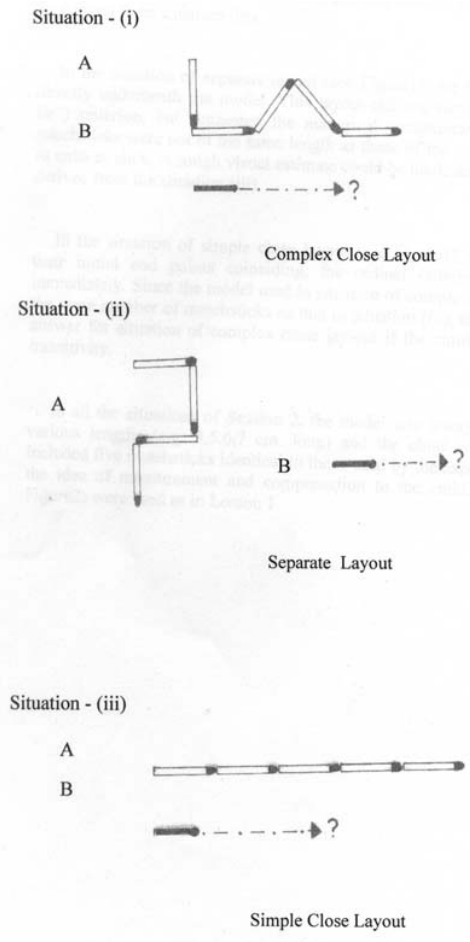

Fig. 1: Lesson 1/Session 1

In the situation of separate layout (see Figure1), the road to be constructed was not directly underneath the model. This layout did not suggest the ordinal ("going just as far") criterion, but suggested the numerical comparison.

However, since the child's matchsticks were not of the same length as those of the model road, they could not serve as units as such. A rough visual estimate could be made and the correct solution could be derived from the situation (iii).

In the situation of simple close layout (see Figure 1), both roads were straight with their initial end points coinciding, the ordinal criterion gave the correct solution immediately. Since the model road in situation of complex close lay-out was made up of the same number of matchsticks as that in situation (iii), the latter situation provided the answer for situation of complex close lay-out if the child had grasped the principle of transitivity.

In all the situations of Session 2, the model was always made up of matchsticks of various lengths (e.g. 3,5,6,7 cm. long) and the child was given a collection which included five matchsticks identical to those used by the experimenter. This problem gave the idea of measurement and compensation to the child. All the three lay-outs (see Figure 2) were used as in Lesson 1.

In the third session (see Figure 3), the model road consisted of a straight length of wire, while the child has matchsticks of various lengths and had to start his road further to the right than the model. To find the correct solution, some idea of measurement was necessary—one could either start at the indicated point which made the end of one's road coincide with the model and then add a matchstick of the same length as the difference between the starting points of the two lines, or one could first construct a road directly underneath the wire and then displace the whole

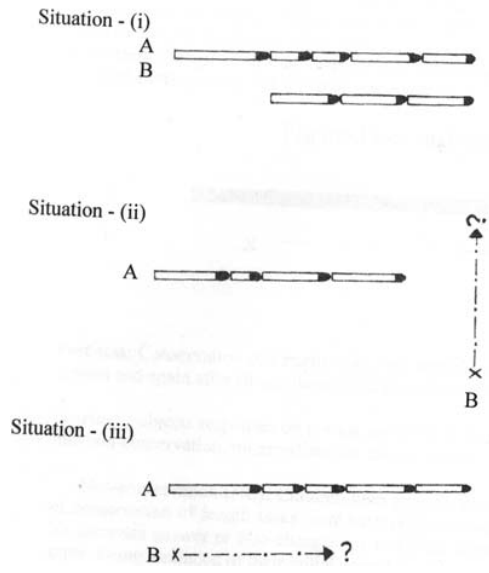

Fig. 2: Lesson 2/Session 2

Fig. 3 Lesson 3/Session 3

construction so as to comply with the imposed starting point. For this problem only one layout was used.

Post-test: Conservation of Length tasks was administered immediately after the training session and again after fifteen days of the first administration.

Scoring: Subjects responses on pre-test and post-test (conservation of length) were scored into non-conservation, intermediate and conservation.

Non-conservation (NC): Children who give all incorrect answers to all the situations of conservation of length tasks

were categorised as non-conservers. The child sticks to his incorrect answer or else changes his mind and says that one road is longer than the other. Being reminded of their initial equal length has no effect on this child.

Intermediate (Int): Children who give either type of responses:

- Faced with the same situation, the children changed their minds as to whether the two lengths are equal or not.
- Some children gave correct answer in only one of the situations.
- Some children influenced by what the experimenter says, for instance, answer correctly when the latter reminded them of the equality of the initial length, or else change their minds after giving a correct answer.
- Some children who gave correct answer were unable to give clear and complete reasons for them.
- In this category a distinction was made between Int-responses (i.e. those responses in which the child gives partially correct answers in both the situations) and Int+ responses (i.e. those responses in which the answer is completely correct for one of the situation and for the other the answer is partially correct).

Conservation (C): Children who gave correct answers i.e., judge equal quantities in each situation. The child is capable of giving compensation and reversibility arguments. Furthermore these children stick to their correct answers even when the experimenter tries to make them change their minds.

Results: Data was analysed qualitatively as well as quantitatively:

Qualitative analysis: Out of the eight children of Int stage, seven (two of Int + and five of Int-) reached the C stage immediately after the training and sustained it till the second post-test. However one child (14F, 7:3 yrs.) named Roshni, remained at its initial level at the first post-test. This can be clearly understood by her responses during the training sessions as follows:

> During the training sessions in the first situation of lesson I, Roshani puts five red matchsticks (each 5 cm. long) for five green one (each 7cm. long) and judges correctly ''अब सड़क हरी बड़ी हो गई है'' further puts two more red matches and answer ''अब लाल सड़क बड़ी हो गई'' क्योकि इसमें अधिक तीलियां लगी हैं।'' If contersuggestion is applied ''हमको हरी सड़क बड़ी लग रही है'' क्योकि हरी तीलियां बड़ी हैं... She answers" ''हरी तीलियां बड़ी हैं... तो क्या... यह (हरी) तीलियां कम भी हैं।'' She shows her inability to make an equal road.
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> In the second situation she puts six red matchsticks and says ''लाल सड़क बडी है क्योंकि ज्यादा तीलियां लगा दी हैं... सीधी सड़क इस (सड़क अ) के बराबर नही बन सकती. .. वैसे ही चित्र बनाना पड़ेगा'' A She then makes Road B same way as the model and for one green match she puts the two red matchsticks and says ''अब लाल सड़क बड़ी है... इन तीलियों से बराबर-बराबर सड़क नही बन सकती।''
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> In the third situation, Roshani puts five red matchsticks for five green, then added two more matchsticks

making the end point coincided and replies ''दोनों सड़क बराबर-बराबर लम्बाई की हैं'' and on counter suggestion she replies ''लाल तीलियां छोटी हैं... हरी तीलियां बड़ी हैं।'' When again come to first and second situation she shows inability and unable to draw conclusion from the third situation to correct her first and second situation.

In the first situation of Lesson 2, she puts three yellow matchsticks (each 6 cm. long) from the imposed point for 7+3+3+6+6 cm. long road and replies ''सड़के बराबर-बराबर लम्बी हैं।'' On countersuggestion she puts one more yellow matchstick and replies ''अब यह सड़क (ब) लम्बी हो गई।'' In the second and third situation of Lesson 2, she uses the same matchsticks as in the model but the situation (iii) does not make her to correct her first situation because her going beyond scheme is strong.

In the third lesson, Roshani tries to make the road equal to 15 cm. long wire haphazardly, without following any strategy and unable to make equal road to wire even after three mistakes.

Three children of non-conservation stage also reached to the final stage at the first post-test and maintained their performance level till the second post-test, four children progressed partially reached Int-level, while nine children remained at non-conservation stage.

The four children who progressed to Int- level from non-conservation stage made further progress between the two post-tests. Two of them (15M and 13M) reached the final stage, and two Int- level at the second post-test. Out of nine non-conservation children at the first posttest two children reached Int + level, one at Int- level and six children showed no progress at all. The responses of a child named Naushad Ali (13M, 7:4 yrs.) who reached the final stage are given below:

In the situation (i) of Lesson 1, Nausad puts five red matchsticks in a straight line (according to the number of matchstick) and says ''दोनों बराबर-बराबर लम्बाई की सड़क हैं - ऊपर वाली सड़क मुड़ी हुई है जबकि मेरी सड़क सीधी है'' and on counter suggestion, he whisper ''और तीलियां लगाने से सड़क (ब) बहुत बड़ी हो जायेगी'' and suggests to make the Road A straight, then adds one red matchstick to road B accepting the compromise solution, since the difference in length is now less and the difference in number not too great. In the second situation Nausad puts four red matchsticks for four green ''दोनों बराबर-बराबर सड़के हैं... क्योंकि दोनों में चार-चार (तीलियां) हैं'' and on countersuggestion he puts one more red matchstick accepting the compensation between the two matchsticks ''हरी तीलियां बड़ी हैं... इसलिये अधिक लाल तीलियां लगानी होंगी'' He responds to the third situation as to the second situation. When again come to the first situation he does not accept seven red matchstick for the five green by saying ''सड़क बहुत बड़ी हो जायेगी''

In Lesson 2, Nausad is influenced by the level of coincidence ''सड़क बहुत छोटी है लेकिन आगे तीलियां लगाने पर यह बड़ी हो जायेगी।''

On counter suggestion he spontaneously finds the solution of making the road start from the same point as the model and then shifting the whole construction to the right. Nausad immediately solve the problem of lesson 3, in a similar way as in Lesson 2. He puts three red matchsticks for the 15 cm. long wire.

Finally, a child (14F, 7:3 yrs.) who gave initially Int-response did not progress even between the two post-tests.

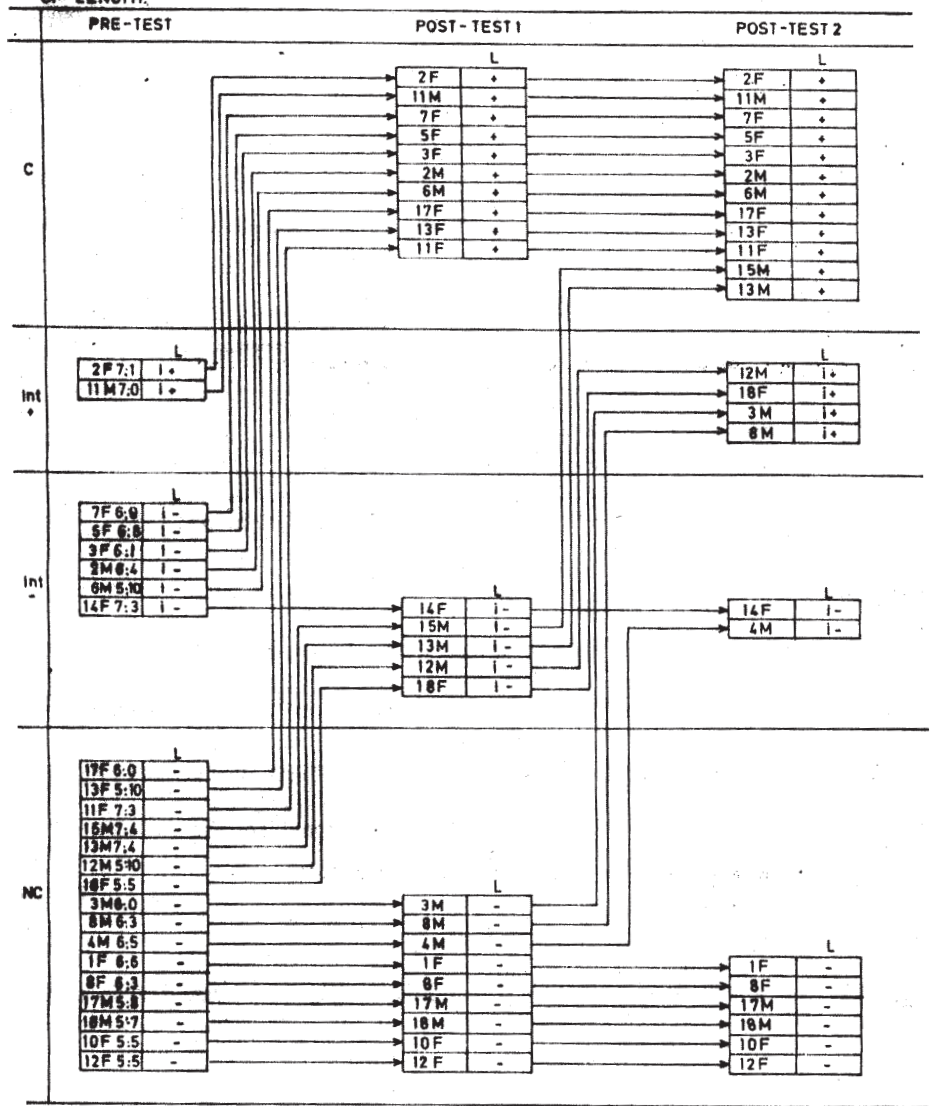
The results of a control group (see Figure 5) who were not administered the training but were given the same pre-test and post-test were different from those of the experimental group. One child (16F, 6:1yrs.) regressed to non-conservation stage from Int-. at the pretest, this child gave partially correct responses in both the situations e.g. in the Situation (i) , she answered "both the roads are of equal length.... Because both ends here (by pointing the end point from finger). When asked whether both will walk equal or one has to farther walk, she said, "You have to walk farther because you have to walk zigzag". On countersuggestion, she maintained her answer "Both the roads are of equal length because this road (Road A) has become small/little....".

Analysis of responses during the training: Lesson 1 elicited a variety of responses which indicated clearly the nature of the difficulties encountered by children and the conflicts arising in the children's mind when they had to compare their different solutions. The different types of solutions shown seemed to follow a developmental order;

- Most of the children started giving with five red matches (each 5 cm. long) (because the model road is made up of five green matches, each 7 cm. long) but they differ in their reasoning. In the first category, there were children who put five matches in a straight line but explained that B road (made up of red matches) was longer than A (made up of green matches) because former went beyond latter. But the same time they did not remove the match from road B, because there were five matches used in the road A. They felt a conflict between the number of matches and the level of coincidence.
- In the second category, there were children who gave responses like the first category, but they did not came to right conclusion after the third situation was presented to them (e.g. 10F, 11F).
- Thirdly, there were children who made up a compromise solution. For Situation 1, they put five red matches in a straight line and declared that both the roads were of equal length because road A was curved, e.g. 15 M, 13 M. This solution may be considered a step forward since the difficulty of the overpowering "going beyond" principle is overcome. However, it is far from perfect, since the total length is simply judged by the number of matches.
- Fourthly, some children put five red matches and declared that even now Road A is bigger. Most of these children corrected their mistakes

FIGURE - 4

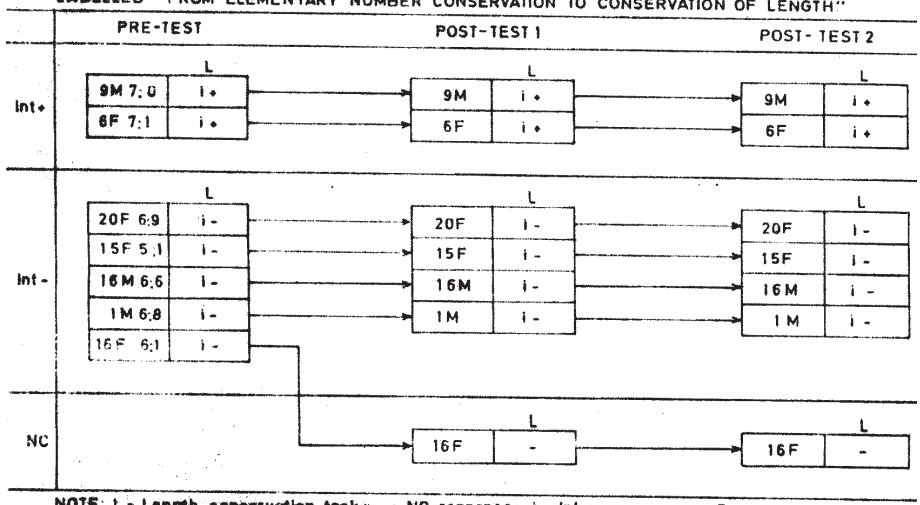
SHOWING PROGRESS / LACK OF PROGRESS OF THE EXPERIMENTAL GROUP SUBJECT' FROM ONE STAGE / SUBSTAGE TO SUBSEQUENT STAGES / SUBSTAGES AFTER THE TRAINING PROGRAMME LABELLED " FROM ELEMENTARY NUMBER CONSERVATION TO THE CONSERVATION OF LENGTH."



NOTE: L = Length conservation task; – = NC response; I = Int response ; + = C response ; M = Male subject ; F = Female subject ; Subjects are identified by numbers 1, 2, 3 etc.

FIGURE - 5

SHOWING PROGRESS / LACK OF PROGRESS OF THE CONTROL GROUP SUBJECTS' FROM ONE STAGE / SUBSTAGE TO SUBSEQUENT STAGES / SUBSTAGES FOR THE TRAINING PROGRAMME LABELLED " FROM ELEMENTARY NUMBER CONSERVATION TO CONSERVATION OF LENGTH"



NOTE: L = Length conservation task; – = NC response; i = Int response; + = C response; M = Male subject; F = Female subject; Subjects are identified by numbers 1, 2, 3 etc.

after third situation was presented, e.g. 4M, 2F.

- Fifthly, some children realised the independent length of green and red matches from the very beginning and showed their inability to make a road equal to Road A because their matches were shorter than the green matches, but after the third situation they came to the right conclusion, e.g. 12F.
- Sixthly, children who put seven red matches in a straight line at once but declared that green road (model road) is shorted than red one (subjects' road) but if experimenter made that (green road) straight both would be of equal length e.g. 6M, 14F.
- Lastly, the children who put seven red matches in a straight line immediately and reasoned that for five green, one should put seven red because green were longer and red were shorter.

In lesson 2, a variety of responses were given:

- The most primitive type of response was to make road B start at the imposed point, but stop in coincidence with the end point of A, e.g. 5F, 8F.
- At a slightly more advanced level, the children first produced the primitive solution, but then judged B too short and added another match. Having done this, they incorrectly judged that B was longer than A. They continued to waver between the two solutions, e.g. 4M, 14F.
- At the next level, the children immediately made their road go beyond Road A. But since they had

Table: Showing Z values of the proportion of progressed children of the experimental and control groups and their comparison for the training programme labelled 'From Elementary Number Conservation to the Conservation of Length'

	State I: Pre-test- Post-test 1	*State II: Pre-test- Post-test 2*	*State III: Post-test 1- Post-test 2*
TTo =.75 Experimental Group Control Group	- 1.89* - 4.60**	- 0.47 - 4.60**	-2.17* -4.60**
TTo =..50 Experimental Group	0.81 (.40 = 1.80*)	-2.03*	-0.00**
Control Group	-2.65**	-2.65**	-2.65**
Difference between experimental and control group	2.47**	2.47**	2.18**

to work with matches of various lengths, they could not simply pick any match and place that at the end of their road B to make correct compensation. They had to find one of exactly the right length. Several children chose their final match at random, arriving at an approximate solution, e.g. 3M, 6M, 11M, 3F, 1F.

- At the most advanced level, various methods were used to produce a correct solution, e.g. 15M (Vasu Kumar) put 6+6+6+7 cm. long matchsticks from the imposed point for 7+3+3+6+6 cm. long road.

In lesson 3, a variety of responses were furnished.

- Firstly, children who showed inability to make an equal road from the imposed point, and if experimenter suggested to overcome the coincidence level, they rejected the suggestion by saying that Road B would be longer e.g. 10F (Shalu Tewari) put one more match below.
- Secondly, children who overcome the 'going beyond' situation haphazardly to complete the road, e.g. 1F, 4M, 18M.
- Thirdly, children measured length between the left ends of the sticks e.g. 5M (Dilshad) put three red matchsticks.
- Lastly, children immediately put three red matchsticks from the imposed point without measuring.

Quantitative Analysis: Results of qualitative analysis show that intervention programme lead to progress in the acquisition of conservation of length but it does not reveal whether the progress made is significant. Thus, in order to make a firm decision, it is necessary to subject the results to statistical analysis. Z values were computed for the experimental and control groups separately on more stringent criteria of TTo = .75 and subsequently slightly less but theoretically justifiable criteria of

TTo = .50. Z values for making a comparative assessment of the progress made by the experimental and control groups were also computed.

When TTo = .75 was used as a cut off point for the experimental group the results (see table) revealed negative and significant value (Z = -1.89, -2.17; p< .05) at the first and third state, and negative and insignificant value (Z= -0.47, p> .05) at the second state. For the control group values turned out negative and insignificant (Z = -4.60 at all the three states; p < .01). All in all no significant progress for the experimental as well as control group was indicated when more stringent cut off point TTo = .75 was used.

Using the TTo = .05 as cut off point the results (see table) revealed positive and insignificant value (Z = 0.81; p> .05) at state I, positive and significant value (Z = 2.03; p< .05) at state II, and nil i.e., Z = 0.00 at state III for the experimental group while for the control group, value turned out negative and significant (Z= -2.65; p<.01) at all the three states. The result on the whole indicated significant impact on the experimental group, while control group showed no progress.

When progress for experimental and control group compared and examined, the results turned out positive and significant (Z = 2.47, 2.47; p< .01, Z = 2.18, p< .05) in favour of the experimental group at all the three states respectively indicating thereby significant training impact on the experimental group.

Discussion: The aim of the training programme labelled " From Elementary Number Conservation to the Conservation of Length" was to facilitate the acquisition of conservation of length. The programmes were designed to see that when elementary number conservation had been acquired, whether the system of operations bearing on a number of elements could be extended directly to the conservation of length (because the number of elements when put together form a certain 'length') or conservation of length does also show complex relationship. Results indicated that only more than 40 per cent progress was observed immediately after the training but got raised to more than 50 per cent progress at the second post-test. Approximately, similar amount of progress was found by Inhelder et.al. (1974).

In the present study, children selected for training were those who had qualified the number conservation problem and were transitional or preconserver for the length conversation problem. Thus these children were at the state of structural mixture and therefore, would likely be able to construct the concrete operational structure for length conservation than those children who were strictly at intuitive operational level i.e., displayed no measured structural mixture (Strauss and Langer, 1970; Langer and Strauss, 1972). Studies by Beilin (1965), Turiel (1969) and Inhelder and Sinclair (1969) also indicated that children who displayed structural mixture were more likely than those who displayed no measured structural mixture to progressively transform their cognitive structures and thereby higher level of equilibrium.

Inhelder and Sinclair (1969) attempted to determine whether the acquisition of length (for which subject

was intuitive) could be facilitated by applying numerical operation (for which subject was operational) to the evaluation of length. The post-test results showed that 35 per cent of the subjects made no progress at all. Of the remaining 65 per cent, slightly more than one-fourth was assessed to have applied the concrete operational structures to both number and length conservation problems.

Number and measurement are based on isomorphic operatory structures: measurement is constructed from a synthesis of displacement and additive partitioning and inclusion. However, the first measurement concept (length) is achieved later than that of number (Inhelder et. al. 1974).

The results of children who had made most the progress during the training sessions and at the post-tests provide further evidence that these new acquisitions are not the result of a simple generalisation of previously acquired knowledge to a new context, but of a true reconstruction on a new level. This reconstruction is analogous to that resulting in a child's grasp of conservation of numerical equivalences,

In the acquisition process of the notion of length the children become aware of conflicts. The reasoning based on one-to-one correspondence schemes clashes with inferences drawn from frontier effects. When the children understand that correspondence judgement need not contradict configural features, they start to attempt to solve other problems in similar way. Indeed, when subjects at this stage were asked to place matches end to end to form a road of the same length as a model, a whole range of attempts to coordinate the two different methods of length evaluation was observed. In fact, before they discovered that they needed more matchsticks in their road because theirs were smaller than those in the model and that "going beyond" did not necessarily mean "being longer", the children often tried out a number of compromise solutions, which were very instructive as regards the regulatory mechanism involve. Thus the training situations are designed to present the child simultaneously with several possible approaches to a particular problem, which, at his cognitive level, are incompatible. The material itself is only of secondary importance, as is shown by the fact that those children who were not intrigued by the contradictory results of the two methods of length evaluation made little or no progress.

The major implications of this study are on the designing and development of appropriate teaching-learning strategy for children. The findings suggest that the acquisition of concept of conservation of length can be facilitated by inducing cognitive conflict in children. It, therefore, appears that appropriate teaching-learning strategies can accelerate the acquisition of various conservation concepts. Proper designed method based on Piaget's theory of cognitive development should find an important place in the teaching programme of elementary schools. First of all, the teacher should bear in mind the central role that children play in their own learning and try to make learning experiences as active as possible. Second, the teacher should adopt pedagogical strategies designed to make

children aware of conflicts and inconsistencies in their beliefs. Third, rather than suppressing the wrong notions, the teacher must bring them out to forth restructure them and then integrate them with other notions. Because any attempt to skip an intermediate stage or to cue out the wrong notions is likely to result in hindering later learning. When earlier concepts are shaky, they will not serve as foundation that generates high order concepts.

Since teaching strategy and curriculum are dependent on the educator's awareness of the child's capacity to deal with material, it is necessary for the teacher to identify the child's level of cognitive structures. The matching of curriculum and teaching strategy to the intellectual level of child is a tricky issue. It is easy to confuse the child's manifest level of cognitive competence with his "true" understanding. For example, just because the child uses the word "animal" correctly in everyday context does not mean he knows or can define concept.

In Piagetion curriculum teaching is a two-step process of diagnosis followed by instruction in the concepts for which the child is ready. The long-term implication of diagnostic prescription is that teacher training programmes must be oriented to train teachers acquire diagnostic skills as well as pedagogical skills.

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