Abstract

The experimental research is focused on logical thinking development mechanisms and determinants finding out. Possibility and efficiency of conservation principle formation at preschool children through formation of knowledge about classification and seriation logic operations structures is verified. New methods of classification and seriation training were developed. Knowledge formation about compositions and structures of classification and seriation logical operations made preschool children able to shift from pre-operational to concrete operational logical thinking stages. This is the way knowledge about logical operations structures is one of the logical thinking development determinant.

1. Introduction

The problem of logical thinking development is the problem of logical thinking development mechanisms and determinants finding out in order to develop effective methods of the intellect formation in children.

The most elaborated theory of intellectual development in the child psychology is operationalized concept of thinking of Jean Piaget [1]. According to the Piaget theory, logic is not inherent initially, but is formed gradually. The problem of intellect development is to analyze how the subject can learn all the objects more adequately, that is objectively. Objectivity is not given to the child from birth, and for its understanding it is necessary to build a series of successive structures, coming nearer to it. There are four stages between nonobjective-objective reflections of reality: sensorimotor intelligence, pre-operational, concrete operational and formal operational

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stages. The concrete-operational structures of intellect are logical operations such as classification, seriation, and understanding of the principle of conservation. Conservation principle understanding is a criterion of operational stage achievement.

There are many strategies of conservation principle understanding formation where success in forming is achieved in most cases fully or partly. The formation using learning of verbal problem solving rules [2], [3], using model behavior observation [4], [5], [6], [7], on the basis of invertibility training [8], compensation training [9], matching one to one objects training [10], using learning of invariant object characteristics extraction [11], [12], [13], [14], measurement action formation [15], [16] etc.

According to Piaget's ideas formed classification and seriation logical operations, being the most elementary groups, presuppose the emergence of reversibility and conservation of the whole. In his opinion, one of the first major operational systems is the classification, i.e. inclusion classes in each other. A second equally important operational system is seriation, i.e. combination of asymmetric transitive relations in the system. The classification and seriation logical operations emerge as the product of coordination of combination, separation, regulation and establishing correspondences, which have found a form of reversible systems. Reaching of the reversibility can be recognized by the appearance of a child's understanding of the principle of quantity conservation (substance, weight, volume, etc.). Consequently, the understanding of conservation can be considered as a result of the availability of logical operations of classification and seriation [17]. However, the possibility and effectiveness of conservation understanding formation by children through the formation of their logical operations of classification and seriation has not been experimentally tested so far.

The experimental-genetic method that was proposed by Vigotsky for studying mental processes [18] and the development of this method in the framework of the activity approach provide a new attitude to the experimental verification of Piaget’s ideas about the sequence of concrete-operational structures formation of children [19], [20], [21], [22] etc.

The results of our previous experimental studies showed the existence of a statistically significant positive correlation between the levels of formation of classification and seriation logical operations and the levels of conversation principle understanding [23]. However, the nature of these relations (causal or correlation) remains unclear. If the Piaget's hypothesis about the emergence of reversibility and conservation of the whole as a result of the availability of logical operations of classification and seriation is right, it will be possible to form the conservation principle by forming of classification and seriation logical operations.

2. Research

2.1. Hypothesis

Conservation principle formation by preschool children is possible through the formation of composition and structure of the classification and seriation logical operations.

2.2. Participants and procedure

Subjects: 54 children aged 5.5 – 6.9 years old. They were divided into two groups (basic and control) of 27 persons each.

1) Basic group: conservation principle understanding was formed through the establishment of classification and seriation operations;

2) Control group: formation was not held. The understanding of the conservation principle could only arise as a result of spontaneous development of logical thinking in this group.
The experimental study included 3 stages - diagnostic, formative, and control.

I. Diagnostic stage is the same for both groups of subjects. The purpose is to find out the original level of the conservation principle. The subject is offered to solve several problems on the conservation principle understanding of discrete quantities, length, volume, weight.

II. Formative stage is different for two groups of subjects. Only the basic group subjects are trained. The purpose is the formation of conservation principle understanding through the formation of composition and structure of the classification and seriation logical operations.

III. Control stage. At this stage the subjects of both groups solve the problems of understanding on Piaget's conservation principle, which they were given in the diagnostic stage of the study.

The first control check was held not earlier than one and a half or two weeks after formation. Second check was held not earlier than one month after the first control check.

2.3. Methods

Material: 16 sets (collections) of objects that differ in colour, form, size, material (8 sets for classification, 8 sets for seriation).

Method of the conservation principle formation: Conservation principle formation is realized by parallel step-by-step formation of classification and seriation logic operations compositions and structures during 6 lessons.

The composition and structure of the classification logical operation:
1) Identification of the distinctive properties of the objects;
2) Determination of the content of selected properties;
3) All the possible divisions of class to the opposite subclasses based on the contents of the selected properties;
4) The identification of the property, which is the same for all the objects;
5) Comparison of class volume with the volume of its constituent subclasses.

Procedure:
A. The understanding of the composition of classification logical operation.
B. Mastery of the composition of classification logical operation.

The composition and structure of the seriation logical operation:
1) Identification of the distinctive properties of the objects;
2) Determination of the content of selected properties;
3) Making series of objects by selecting them considering their selected properties on the basis of the algorithm which is reported by the experimenter. To make series it is necessary to select the object whose property is more pronounced than other subjects properties, and put it first in the line; from the remaining objects it is necessary to choose the one with more pronounced selected property and put it second, from the remaining subjects you need to choose the one with more pronounced selected property and put it third, etc. From the two remaining objects you need to choose the one with more pronounced selected property and put it last but one, put the remaining object last in the line.

Procedure:
A. The understanding of the composition of seriation logical operation.
B. Mastery of the composition of seriation logical operation.

Classes are held individually with each child once a week. Classification logical operations and seriation logical operations are formed during each class. Duration of the class is 15 - 25 minutes depending on the number of classes, the number of tasks which were solved by the child during each class, and individual characteristics of the child.

The first four sets of objects for the formation of classification logical operations and seriation logical operations are used in the first class. During the following five classes (classes 2 - 6, one per week) a child masters compositions and structures of classification and seriation operations through the solving of classification and seriation tasks. In the second class the child solves tasks with four sets of subjects, which were used by the experimenter to explain the methods of classification and seriation at the first class. In each class, beginning with
the third, one task on the classification and one task on the seriation are added. The child solves the tasks which he has already done at the previous classes and gets new ones. At the final class, the child works with eight sets of objects for classification and seriation.

2.4. Results

The results of the conservation principle formation in the basic group subjects are presented in Table 1. The column A includes the quantity of subjects participated in the class (number of effective calls: (+) – the class was held, (-) – a child missed the class). The columns B, C, D, E include the results of the control check of classification, seriation logic operations and conservation principle understanding (1 check – in a half a week or two weeks after formation, 2 check – in a month after the first control check): (+) – is formed to the full, (-) - is not formed, (n) – control check cannot be made for objective reasons.

Table 1. The results of concrete-operation structures formation in basic group subjects

<table>
<thead>
<tr>
<th>A. Quantity of subjects (number of effective calls)</th>
<th>B. Classification</th>
<th>C. Seriation</th>
<th>D. Conservation, 1 check</th>
<th>E. Conservation, 2 check</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 subj. (+5 participate /-1 miss out)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3 subj. (+2 participate /-4 miss out)</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3 subj. (+4 participate /-2 miss out)</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
</tbody>
</table>

As we can see from the Table 21 basic group subjects completed the work on formation of conservation principle understanding without violating the experimental scheme. All these children were able to solve control tasks of Piaget on the classification, seriation and conservation (in the two tests) correctly.

6 out of 27 children from the basic group violated the scheme of the experiment for reasons beyond the experimenter. 3 out of 6 subjects dropped out of the course of the experiment. The other 3 subjects were presented only at 2 classes, which did not allow the subjects to achieve understanding of the conservation principle, but classification and seriation logic operation were formed. This fact is really interesting, because the difference between conservation and nonconservation subjects is only in the number of lessons. Therefore periodicity of classes and lack of missed classes are important in order to achieve results.

All control group subjects (27 persons) failed to solve the conservation Piaget tasks invited them at a control stage.

The hypothesis of our study was experimentally proved.

3. Conclusion

It is possible to form the conservation principle understanding using the formation of knowledge about compositions and structures of classification and seriation logical operations. Material assignments and the number of tasks varied during the experiment. The difference between retentive and nonretentive basic group subjects consisted in a number of different sets, which were used to mastery the logical operations and, therefore, the ability to transfer the generated transactions in new situations. Thus, we can assume that classification and seriation logic operations are not just groups (as Piaget confirmed), but groups with specific characteristics (especially generalization and durability).

For the first time the possibility of some concrete-operational intelligence structures formation (conservation principle understanding) through other specific-operational intelligence structures formation (the composition and structure of classification and seriation logical operations) was shown.

It was experimentally proved that causal connection (but not only statistically significant positive correlation) exists between the formation levels of classification and seriation logical operations and conservation principle
understanding by preschool children. Thus, Piaget's theoretical concepts, telling that the understanding of conservation can be seen as the result of the availability of classification and seriation logical operations were experimentally proved using the experimental genetic method that was proposed by Russian psychological school and developed within the framework of the activity theory. It is a convincing illustration of how divergent and contradictory mental nature explanation theoretical approaches can complement and enrich each other.

Knowledge formation about compositions and structures of classification and seriation logical operations made preschool children possible to shift from pre-operational to concrete operational logical thinking stages. This is the way knowledge about logical operations structures is one of the logic thinking development determinant. This idea can be used for education methods designing. Concrete operational structures formation methods that were developed within the current research can be used in the process of preschool children preparing for school study.

References

[22] Ilyasov II. *Struktura protsessa uchenija [The structure of the learning process]*. Moscow: Moscow University Press; 1986.