

How to Develop Meta Cognition to Thinking Process in order to Improve Investigation Skill

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ABSTRACT

In this paper a special way to use intelligence tests in order to strengthen the student teachers' meta-cognition and their ability to master the skills was examined. The objective of this exercise is to prepare the students to use these skills, which are relevant also for carrying out scientific experiments. These student teachers reported that the process of carrying out the experiments became more transparent after their experimenting with the matrices.

Keywords: Meta-Cognition, Thinking Process, Solving Matrices, Investigation Skill, Melting Ice Cubes.

THEORETICAL REVIEW

Gagne (1) defines two levels of skills needed for carrying out scientific investigations. In the lower level, the skills of observation using time and space, classifying, computing, anticipating (foretelling) using numbers, making measurements and concluding, are included. While the higher level of skills contains the ability to identify the variables, separate and control them are found among others. Zohar and Veinberger (2) (3) define three levels of skills required for carrying out scientific investigations. The low level of thinking includes the skills of operating relations, sensory insight, motor and sensory perception, space and time coordination, counting and measuring. The middle level of thinking includes: Predicting, inferring, communicating and classifying. While the high level of thinking includes the strategies: isolation of variables, logical deduction, proportional thinking, reflective thinking and probabilistic thinking. In this paper we will concentrate on the high level of thinking. According the Theory of Piaget (4) (5), this level of thinking is based on the skills as probability, propositions (if ... then), (logical deduction), correlations and proportion : direct and inverse ratios and proportions. Most of these skills are identical to the previous ones.

Some of these skills can be identified by analyzing the Progressive Matrices of Raven (6), and to find the way to suggest the correct solution to each of them. In order to solve an eight +one Raven Matrice, the students need to enlarge their observational abilities to recognize colors and forms, and develop their spatial organization ability. The need to count and distinguish between horizontal and perpendicular, to observe the graduate changes between one form to the other, in each row and column. All these skills are similar to Gagne's (1) low level skills. The skill of classification is used in order to define the laws governing the changes that occur in the rows and columns

of the Matrices, the special variables concerning these laws should be defined and controlled, for each problem. The students then infer these laws by operating logical thinking. Other spatial concepts such as dimensions, inside or outside, close to or touching each other, and so on, are also exercised. The use of the Raven's matrices (6) creates awareness to the thinking processes:

- ◆ Self criticism – Which solution is more correct?
- ◆ Which variable influences the solution? –
- ◆ Coverage of the shape becomes complete and the area is increased as we are advancing.
- ◆ Concluding according two sets of data
- ◆ (Three objects in each column and in each row)
- ◆ Variables, isolation of variables, dependent and independent variables
- ◆ Dependent variables – shape and direction (vertical and horizontal, oblique line, cutting straight lines):
- Far and close
- Thick and thin
- ◆ Independent Variable - the place

The same thinking processes are used for solving also other problems.

Exercises exemplify direct proportion as a problem in science: Concentration of solutions – such as Concentration of salt in the water, for example: the Mediterranean Sea.

Example of problem concerning defining variables: In cold water the salt melts quickly, the sugar melts slower, then flour becomes into many blocs (See table 1).

Table 1: The Required Skills
The ability to control variables and operate ratios

Direct Ratio	Inverse Ratio
As the quantity of the ice increases, the melting process becomes slower - the time needed is longer.	As the temperature increases, the process of melting becomes quicker - the time needed is shorter.
Control of variables	

Further defining variables: temperature and phase change.
Melting - Solid melts while creating solution Water
Al-magnetic Ashlegan solid.

Evaporating - Melted liquid Evaporates Melted solid does not evaporate.

For example: Substance that melts in the water does not disappear.

When we put a solution of salt in water under the sun, the water evaporates, the salt remains.

The pace of the evaporation increases when the temperature becomes higher.

Consolidating - The water evaporated. Lilach blocks of Al-magnetic Ashlgan are left in the cup.

The research problem stated here is how to make pupils conscious of their thinking processes, which will help them to solve problems taken from the intelligence tests (The Standard Progressive Matrices of Raven(6)). At the same time, when the pupils are aware of these thinking processes, it is hypothesized that they will be able to enact the same thinking processes of identification, separation and control to perform controlled scientific experiments. The examples of such scientific experiments are the identification of the variables needed to solve the problems of estimating the time spans needed for the melting of ice cubes in varying conditions. To perform this task, the pupils should be able to identify the dependent and independent variables significant to these physical processes, i.e. the time needed to melt the ice cube, and the temperature, that exists, while the process of melting is taking place.

In the Raven Matrices, these variables are the intentional changes made in the Matrices' forms and the effect of those changes on the same forms. The dependence of the time span of melting on the temperature exemplifies inverse proportion. Since, as the temperature becomes higher, the time span becomes shorter. This proportion resembles problems where the forms in the matrices become smaller or less complicated during the process of change in the rows and in the columns. On the other hand, when the volume of the ice cubes is changed, the direct ratio logic is in action. This is similar to solving problems of matrices, where the forms become bigger or gradually more complicated. Thus, we see that to plan, execute, and infer the conclusions from a scientific experiment, the same logical processes as regarding to the processes of solving intelligence test problems are used.

The gradual changes in the forms presented in the test, consisted of the matrices, were demonstrated by computer graphics. The computer is used to display the similarities between skills needed to solve the logical problems, carry out scientific experiments and analyze their results.

RESEARCH PRESENTATION

The tool was presented to 16 pre-service teacher students, who major in science education. They tried to identify the concepts, the changes and the laws that lead to the solution of Raven Matrices of changing levels. Then, they used the same skills to handle the problem of the melting ice cubes.

Scientific Experiment: Melting Ice Cubes

High level of thinking is used during the process of melting the ice cubes. Three independent variables are manipulated in this experiment: temperature, quantity of water and quantity of ice, while the dependent variable is the time of melting

The objective of this experiment is to check how the variables affect the speed of the melting.

Logical Problems: Solving Matrices

Logical problems, in the form of Progressive Raven Matrices (6), are displayed over the computer's screen. The participants solved the Progressive Matrices of Raven (6) through the computer graphics. During the completion of the matrices, the participants check each change in the forms presented in the test, to find out if it matches the actual changes in the forms of the Matrix. The analogy of the steps taken in solving matrices problems and designing the scientific experiment were demonstrated by PowerPoint presentations.

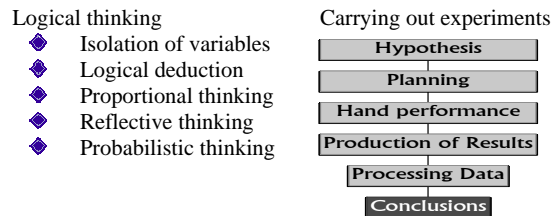
FINDINGS

The student teachers reported that the process of carrying out the experiments became more transparent after their experimenting with the matrices.

SUMMARY AND CONCLUSIONS

Intelligence performance tests testify the skills as spatial perception, visual perception, variables isolation – separation, discrimination of similarity and variation, creating correlations, etc. The concepts included in intelligence tests and also for doing scientific experiments are as following: horizontal, vertical. Advance and backward, correlation, counting, right and left, up and down, integer and portion (fractions), big and little, far and close, between and in forms, cutting forms, thickness, inside or center.

There is a correspondence between the skills of logical thinking and carrying out experiments.



The levels of experimenting are: collecting data, formalizing hypothesis, planning experiment, carrying out experiment and collecting information through observing and measurements, getting results, checking hypothesis, communication.

The experiment testified in this research is based on formal operative difficulty. This experiment requires formal thinking.

The thinking skills exercised in learning activities (7) are as following:

- The ability to identify, formulate and define the problem.
- The ability to identify or formulate hypothesis
- The ability to plan an experiment.
- The ability to conclude valid conclusions according to data collected during the experiment.
- The ability to separate and isolate variables.
- The ability of hypothetic-deductive thinking.
- The ability to recognize exposed and hidden assumptions behind deduction or thought.
- The ability to recognize relevant information for solving problems.

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