Journal of Psychological and
Educational Research
JPER - 2011, 19 (2), November, 54-66

DEVELOPING REASONING IN STUDENTS WITH ABOVE AVERAGE COGNITIVE SKILLS

Denisa Boroş *
University of Oradea, Romania

Cecilia Sas **
University of Oradea, Romania

Abstract
Strategies to stimulate cognitive development in general, especially reasoning can be used in the teaching process, being applicable for all children. The present study demonstrates that application of strategies of developing inductive reasoning in children with above average cognitive skills leads to superior performance in all six elements of inductive reasoning. The training program used is based on theories of cognitive modificability, especially the studies by Hamers, Koning, & Sijtsma (2002) and includes 120 tasks, divided into 6 categories of inductive reasoning: generalization, recognition of relationship, discrimination, differentiation of relationship, cross classification and system formation. The study included 30 primary school children with above average cognitive abilities, using a pretest-posttest-follow-up design.

Keywords: cognitive modifiability, development acceleration, inductive reasoning

Introduction

Understanding the cognitive mechanisms in general, of the way in which thinking functions, in particular, has been a central approach of knowledge since Ancient times.

One of the fundamental goals of cognitive science today is to reveal the functioning of the cognitive processes of children in school learning situations,

Correspondence concerning this paper should be addressed to:

* Ph.D. Student, University of Oradea, Faculty of Socio-Humanistic Sciences, Department of Educational Sciences, University street, no. 3, Oradea, Bihor, 410087, Romania. E-mail: *denisab18@yahoo.ca*

** Ph.D., University of Oradea, Faculty of Socio-Humanistic Sciences, Department of Educational Sciences, University street, no. 3, Oradea, Bihor, 410087, Romania. E-mail: *sascecilia@yahoo.com*

but also to articulate fundamental, multidisciplinary research with regard to the development of the human being with learning and with the educational process. Questions that can be formulated in this respect are: How does the child learn? What are the cognitive processes mobilized? How can be explained the disorders that manifest themselves in the learning process? How can we stimulate the development of mental processes involved in the act of learning?

The development process is explored in the many interactions of the structures that contribute to the development / construction of cognitive functions. Recent developments in neurobiology allow the more precise articulation of the different layers of explanation - neurobiological and psychological - of cognitive development. Research is mainly oriented towards issues such as those related to acquisition of specific knowledge or ability to advance acquisition at increasingly smaller ages (early acquisition of information). In general the knowledge process is approached as an adaptive activity performed in a given context.

Issues linked with the development of the cognitive plan must be directly related to ensuring the success of school, on one hand, with the possibility of accelerating cognitive development, on the other. However, most theories of cognitive development or of school success or have been developed without taking into account activity in the class, teaching activity. That, because approaches lacked the holistic principle, a principle is required in the analysis of cognitive development, without disregarding the context in which it is made.

In a multidimensional approach, Sternberg and Davidson (*apud* Hart, 1991) react to the weaknesses of psychometric arguments, especially in tests measuring the intellectual coefficient. Researchers who enrol in the direction of multi-dimensional approaches state that gifted students differ from others in their superior ability to process information.

Sternberg (1983) explains intellectual endowment through four operational processes of school intelligence:

- Superior abilities in executive processes/functions, such as the identification, de selection procedures, selection strategies, solving strategies;
- The ability to make inferences (strategy of thinking, consisting in deriving a statement from another or extracting a given fact or assertion of all consequences that may result) and to apply them in new situations and areas;
- The ability to lean, to connect new information to information already memorized;

- Superior ability to receive external stimuli from the environment.

Regarding the specific stimulation of children with above average intellectual endowment - and not only - three categories of specific educational services can be identified: *development/enrichment, development acceleration and integration*.

Development requires intervention, stimulation and support to children in the usual program in which children are. Development can be achieved by accelerating the learning rhythm, giving children a greater variety of themes, issues, problems or giving them more complex explanations (Gagné, 1986).

Acceleration represents a set of administrative measures which allow this category of children to cross / to go through various stages of the school system at faster rates. This is a controversial aspect in the school environment in general. However, many research studies have demonstrated that concerns about the possibility of some disadaptative phenomena after acceleration have no objective basis.

Forms / strategies for the development or acceleration usually require at least some form of support for integration, whether it's the class-group, or it's about the integration into special classes or schools, throughout the school period or only for limited periods of time. Numerous studies have demonstrated many advantages of integration, both in terms of cognitive progress and in the socio-emotional plane (Gagné, 1986).

Invoking the right of every student to benefit from an educational system which promotes the full development of personality, different pressure groups require schools to allow gifted and talented children to turn their potential to maximum account. The ultimate argument of these militants of endowment is that we should rely on young people with high skills in a society which faces ever more complex problems (Hart, 1981).

The concept of cognitive educability is strongly linked to that of metacognition (Coen, 2000). Cognitive education can be defined as "explicit research done by putting into action a training approach, to improve the functioning of the intellect" (Loarer, 1998). J. Loarer states that intelligence development is achieved through action, mediation and metacognition. Coen sees in these three components the three main theoretical axes to stimulate cognitive development. The Piaget theories according to which knowledge is constructed by the action of the subject interacting with the external environment, and Brunner and Vâgotski's theories that emphasize the role of social mediation in learning knowledge and all other cognitivist studies (Flavell, Brown, Campione etc.) are representative in this respect.

In recent years, many curricula have introduced the practice of learning strategies through specific courses where students learn different techniques of study and approach to knowledge (Buchel, 1990).

The ability, aptitude to think (TA - Thinking Ability) is a tool that can be achieved just as well as cooking, playing tennis or golf, driving or dancing. Learning all of these activities requires a deliberate, conscious and self-determined process, in other words, an effort. Some people will learn more easily than others, both in terms of cooking and in learning tennis, dance and thinking strategies. A natural aptitude unaccompanied by effort and action, by practice, remains inoperative.

When we want to intervene formatively to develop the cognitive plan we should focus on how various cognitive tools, form, shape our different ways of understanding the world. All these raise a number of issues on education.

Inductive Reasoning Development Programs

Research on thinking in general and on the effects of training programs which affect children's performance in induction problems in particular is theoretically and practically relevant, and therefore requires special attention.

Studies in educational psychology focused on the analysis of cognitive processing in situations where students solve inductive reasoning tasks. Research has focused on cognitive processing involved in completing the series, analogies, classifications, categorizations and matrices (*apud* Koning, Hamers, Sijtsma, & Vermeer, 2002).

Feurstein training program (Sternberg, 1983) is based on his own theory of intelligence that emphasizes the meta-componential performance as part of its operation. The program is designed to improve cognitive functioning at the level of input, development and operation of the individual.

Another *inductive reasoning training program* was developed by Klauer (1989), a version in German. For its application in the regular classroom environment, the original version was adapted by De Koning and Hamers in 1995.

Inductive reasoning aims to identify generalizations, rules and regularities. Glaser and Pellegrino (1982, *apud* Klauer & Phye, 2008) state that inductive reasoning tasks have the same basic form or generic property which requires the individual to induce a rule governing a set of elements. There is general agreement that tasks such as classifications, analogies, incomplete series and matrices require inductive reasoning (Büchel & Scharnhorst, 1993, *apud* Klauer & Phye, 2008). Inductive reasoning is characterized by individual examples: its products, detection of rules and some types of processes.

Inductive reasoning requires not only discovering regularities, but also irregularities and diversities. Klauer & Phye (2008) defined inductive reasoning based on three facets: A, B, and C. The comparison involves identifying similarities, differences, or both (Tversky, 1977, *apud* Klauer & Phye, 2008). *Facet A* is *the comparison facet*. Comparison processes produce regularities consisting in the identification of at least one common feature in a series of objects. *Facet B* refers either to the common attributes of objects or to the relations between objects. This facet is called *category facet*. *Facet C* is the *material facet* and specifies the nature of the content of inductive reasoning. A and B are central facets. They will constitute the six classes of inductive reasoning, not taking into account all possible combinations.

Three training programs and appropriate textbooks have been structured as follows:

- Program I for 5-8 years' old children
- Program II for 11-13 years' old children
- Program III for 14-16 years' old children.

Program I is based on nonverbal tasks that is why it can be used in all cultures. The first two are specialized programs for students in mainstream classes, gifted children and children with learning difficulties. The child's cognitive development determines whether program I or II can be used for training. Program III is used for young people with moderate learning difficulties, poor school performance or those who are in the situation of vocational integration.

The inductive reasoning program developed by De Koning and his collaborators (1995, *apud* Koning et al., 2002) is based on the central process of intelligence.

Classification and serialization of objects are considered to be the basis of the same cognitive process as the classification and serialization of sentences in a text, although the visual codes are different, which would correspond to the classification, ordering and finding the typical analogy in tasks used to measure inductive reasoning (Sternberg & Gardner, 1983, *apud* Koning et al., 2002).

The field of inductive reasoning involves transfers between visual and verbal material. However, the transfer does not occur easily (Brown, Bransford, Ferrara, & Campione, 1983, *apud* Koning et al., 2002). Equally, reasoning involves taking advantage of some assumptions and developing arguments, conclusions and/or consequences, inferences/derivations. Reasoning development turns to good account and enhances cognitive endowment.

Objectives

The central objective of this study is to demonstrate the efficiency of an educational program designed for the development of inductive reasoning abilities in second grade with above average cognitive abilities. Equally, we intend to highlight the ways in which, in the usual school environment, the students' cognitive potential can be stimulated.

Hypothesis

We suppose that the proposed educational program contributes significantly to the development of inductive reasoning ability.

Method

Participants

In this study, 30 participants were enrolled, students in grade II, at a school in Oradea. In order to assess the cognitive level of students, we used the SPM application (classical form), referring to the standard developed for Romanian population. Students have obtained performance assigned to level I (higher intellect, meets or exceeds the 95^{th} percentile) and level II + (meets or exceeds the 90^{th} percentile). Average chronological age is 8.68 and the standard deviation is 0.29. Distribution of participants by gender is as follows: 14 boys and 16 girls.

Instruments

To achieve the objectives, we used the Test for Inductive Reasoning (TIR), a test adapted on Romanian school population.

Procedure

In the pretest phase, we applied the test for inductive reasoning to the group of students, in January of the school year. The test was applied, frontally, in pencil-paper version, with its corresponding instruction. In each series, the first items were answered frontally, to make sure that instruction was understood. Answers to these items were not recorded on the answer sheet. The authors of the test recommended that. The test was applied before beginning the intervention program, at the end of the program and 3 months after completing the program.

The intervention was conducted over the period of 10 weeks, having 2 activities per week. Activities focused on developing inductive reasoning skills. Lessons were held by the researcher.

The group benefited from a set of activities spread over a period of 10 weeks. Topics addressed in the training program aim at inductive reasoning components: establishment of similarities, differences and similarities / differences. In the case of similarities, we had in view the generalization dimension (finding the common feature of the 3 elements) and serialization (find the criterion used to form the series). For differences, we included two dimensions: discrimination (identifying the different element) and disturbed serialization (finding the element improperly placed in a series). Establishing similarities / differences involves two dimensions: cross classification (identification of the element that has the most similarities with the target element) and system formation (addition of matrices). For each of the dimensions mentioned above, we built about 20 tasks, with a total of 120 tasks included in the training program. We used both geometric patterns and elements from the surrounding reality. Thus, the theoretical foundation of this training program is rooted in the theory of a group of researchers from the Universities of Leiden (Els de Koning), Utrecht (Jo H. M. Hamers and Adri Vermeer), Tilburg (Klaas Sijtsma).

Presentation and interpretation of results

To verify if the condition of sphericity is met, we calculated the value of the Mauchly's W test; if its value has a significance level lower than 0.05, that condition is not met, consequently we will use the Greenhouse-Geisser correction (*apud* Sava, 2004).

Table 1. Averages, standard deviations and analysis of variance with repeated measurements for generalization

Stage	N	Average	SD	F	Sig.	Effect Size part η^2	Statistical Power
Pretest	30	3.43	0.38	14.930	0.000	0.340	0.999
Posttest	30	4.10	0.88				
Follow-up	30	4.20	0.82				

The Mauchly test for the generalization dimension is statistically significant Mauchly's W = 0.652, $p < 0.05$); Greenhouse-Geisser correction indicates value F (1.48, 43.02) = 14.930, $p<0.01$.

We will proceed to the analysis of repeated, standardized contrasts, in the case of the generalization dimension. In order to highlight the contrast between pretest and posttest, we obtained a 0.317 partial squared eta coefficient, 0.944 statistical power. For the second contrast, between posttest and follow-up, the coefficient is 0.033, statistical power of 0.162.

Table 2. Averages, standard deviations and analysis of variance with repeated measurements for discrimination

Stage	N	Average	SD	F	Sig.	Effect Size part η^2	Statistical Power
Pretest	30	2.80	0.18	3.777	0.054	0.115	0.509
Posttest	30	3.16	0.34				
Follow-up	30	3.16	0.44				

The Mauchly test for the discrimination dimension is statistically significant (Mauchly's W = 0.300, $p < 0.01$), Greenhouse-Geisser correction indicates value F (1.17, 34.11) = 3.777, $p<0.01$. Thus, the pretest-posttest differences are highly significant, the students have developed the ability to identify the different element.

In order to highlight the contrast between pretest and posttest, we obtained a 0.139 partial squared eta coefficient, statistical power 0.533. For the second contrast, between posttest and follow-up, the coefficient is 0.000, statistical power of 0.050.

Table 3. Averages, standard deviations and analysis of variance with repeated measurements for cross classification

Stage	N	Average	SD	F	Sig.	Effect Size part η^2	Statistical Power
Pretest	30	3.00	0.08	11.66	0.000	0.287	0.998
Posttest	30	3.50	0.04				
Follow-up	30	3.53	0.13				

The Mauchly test for the discrimination dimension is not statistically significant (Mauchly's W = 0.893, $p > 0.05$), therefore the condition of sphericity is met. Calculated value calculate $F(2, 58) = 11.66$ has a significance level less than 0.01. The effect size is big, so is statistical power. A part η^2 coefficient means that the factor alone accounts for 28% of the total variance (effect + error).

Table 4. Averages, standard deviations and analysis of variance with repeated measurements for serialization

Stage	N	Average	SD	F	Sig.	Effect Size part η^2	Statistical Power
Pretest	30	3.43	0.07	9.257	0.000	0.242	0.941
Posttest	30	3.90	0.24				
Follow-up	30	3.90	0.15				

F value $(2, 58) = 9.257$, $p<0.01$ indicates highly significant differences with regard to the serialization ability. The effect size is big, obtained results have a significant practical value.

In order to highlight the contrast between pretest and posttest, we obtained a 0.297139 partial squared eta coefficient, statistical power 0.922. For the second contrast, between posttest and follow-up, the coefficient is 0.000, statistical power of 0.050.

Table 5. Averages, standard deviations and analysis of variance with repeated measurements for disturbed serialization

Stage	N	Average	SD	F	Sig.	Effect Size part η^2	Statistical Power
Pretest	30	3.76	0.67	14.23	0.000	0.329	0.998
Posttest	30	4.50	0.97				
Follow-up	30	4.50	1.00				

Calculated F value (2. 58) = 14.235 corresponds to a level p less than 0.01, effect size is increased, which means that there is little chance of committing type I error, the obtained results have a significant practical value.

Table 6. Averages, standard deviations and analysis of variance with repeated measurements for system formation

Stage	N	Average	SD	F	Sig.	Effect Size part η^2	Statistical Power
Pretest	30	3.03	0.24	7.288	0.000	0.201	0.925
Posttest	30	3.53	0.22				
Follow-up	30	3.56	0.30				

The Greenhouse-Geisser Correction of F (1.89, 55.05) has a significance level less than 0.000. Analyzing the average values in posttest and follow-up, we find similar values, which means that the results remain after the intervention program.

Discussions

Presentation of results allows for the confirmation of our hypothesis, namely, the proposed educational program contributed significantly to the development of inductive reasoning ability on students in grade II, with above average cognitive abilities. The greatest average differences were obtained from disturbed serialization. In this type of problem, we have two actions: identifying the improperly placed item and placing it in the appropriate place to form a correct series. We have noted highly significant differences between pretest and posttest, and posttest-follow-up comparisons indicate results stability, assimilation of cognitive skills for inductive reasoning was achieved in the long run.

These abilities which were developed through the program can be stimulated in school or daily activities. Performed activities allow the application of inductive reasoning principles in various contexts. Inductive reasoning involves inducing a property, a rule and a structure.

The theory underlying the program proves its validity, stability and sustainability of results being a condition that supports this issue. For a sustainable learning it is essential that students be taught not only to solve the task, but also to implement the strategies in new situations. The complexity of information in today's society requires that. It is not enough to hold a considerable amount of information if we do not properly apply it. From that perspective, learning should not be regarded as a passive process but as an active and constructive process. In the educational process, each school discipline operates with a series of concepts, rules and principles. Verbal mediators also play an important role.

With regard to the ability to establish similarities, even if the objects differ in terms of perception, students resort to functional similarity, the objects being categorized according to their function. Students focus on group properties which involve relationships between specimens.

Identifying differences, namely distinguishing features is better because the images are presented directly (visual perception) as compared with the situation when we name them (mental image) (Bonchiş, 2004).

Simultaneous identification of similarities and differences is the most complex, successfully solving tasks of this type requires sufficient information and its adequate structuring.

Students can acquire meta-cognitive skills that facilitate inductive reasoning only if they have a rich conceptual representation of the investigated field and if they are interested in that area (Goswami, 2008). Performed activities have met this condition, at this age children manifest a particular preference for processing perceptive material.

Conclusions

Inductive reasoning is not only a means of learning, but also a product of learning; therefore, different educational environments can produce different development of this skill. Thus, a stimulating educational environment provides an efficient basis for a rapid development of inductive reasoning. Inductive reasoning becomes a mental tool that facilitates not only the acquisition of new information, but also their transfer to new situations (Csapó 1997).

Development of thinking, in general, of reasoning in particular, is not only a condition of obtaining academic success but also a sine qua non condition of quality of life at any age, depending on the quality of cognitive strategies that we can put into action. Therefore our ability to think must be systematically cultivated.

With regard to the school type learning, developing reasoning provides assimilation of abstractions embedded in various subject matters. In everyday life, to think logically means to analyze, argue and rationally justify your own decisions. Reasoning, logical thinking is essential in the practice of any profession.

In future studies, in addition to visual material, verbal material should also be used in order to approach learning in a holistic manner.

References

Bonchiş, E. (2004). *Child psychology*. Oradea: Editura Universităţii din Oradea.

Büchel, F. P. (1990). How are learning activities initiated? An epistemological view of mediated learning experience. In R. Feuerstein, P. Klein, & A. J. Tannenbaum (Eds.), *Mediated Learning Experience: Theoretical, Psychological and Learning Implications.* Tel Aviv/London: Freund Publishing House.

Coen, M. (2000). Non-Deterministic Social Laws. In *Proceedings of the Seventeenth National Conference on Artificial Intelligence (AAAI'2000),* 15-21. Austin, Texas.

Csapó, B. (1997). The Development of Inductive Reasoning: Cross-sectional Assessment in the Educational Context. *International Journal of Behavioral Development, 20*(4), 609-626.

Gagné, F. (1986). *Douance, talent et accélération scolaire, du préscolaire à l'université*. Montréal: Centre éducatif et culturel Inc.

Goswami, U. (2008). *Cognitive Development. The Learning Brain.* Hove: Cambridge University Press.

Hart, F. (1991). *Les doués à l'école*. Ottawa: Editions Agence d'Arc.

Klauer, J. K., & Phye, D. G. (2008). Inductive Reasoning: A Training Approach. *Review of Educational Research, 78*(1), 85-123.

Koning, E., Hamers, J. H. M., Sijtsma, K., & Vermeer, A. (2002). Teaching Inductive Reasoning In Primary School. *Developmental Review, 22,* 211-241.

Loarer, E. (1998). L'éducation cognitive: modèle et méthodes pour apprendre à penser. *Revue Française de Pédagogie, 122*, 121-161.

Sava, A. (2004). *Data analysis in psychological research*. *Cluj-Napoca:* ASCR.

Sternberg, R. J. (1983). *How Can We Teach Intelligence?* Philadelphia: Research for Better School.

Received September 15, 2011
Revision received October 11, 2011
Accepted October 21, 2011