

**7<sup>TH</sup> International conference ON  
PSYCHOLOGY  
OF EDUCATION SCIENCES AND  
LIFESTYLE**

Tbilisi - Georgia

March 2021



## **Human need to cultivate abstract thinking**

**Mahmoud Bahrani**

Assistant Professor of Shiraz University, Shiraz, Iran

### **Abstract**

The process of formation of cognition and thinking in human beings begins during the developmental stages from birth. One of its stages is the formation of objective thinking, which followed by abstract thinking. While objective thinking is done by looking at objects and phenomena or their embodiment in the mind, abstract thinking is thinking beyond the apparent aspects of phenomena and objects and is done by leaving aside the material and physical aspects. Since human civilization and progress in various fields of science, literature, culture, art, architecture and engineering are the product of complex mental functions and abstract thinking, cultivating this type of thinking and providing a developmental context for the high-level brain functions should be on the agenda by educational systems. In this article, attention is paid to this important issue through defining abstract thinking in comparison with objective thinking and also its common aspects with critical thinking, the importance of abstract thinking is emphasized and comments related to teaching this type of thinking are made in this article. In this article, with paying attention to this important point, while defining abstract thinking in comparison with objective thinking and also its common aspects with critical thinking, the importance of abstract thinking is emphasized and according to the patience of this article, opinions related to teaching this type of thinking are pointed out.

**Keywords:** Objective Thinking, Abstract Thinking, Critical Thinking, Education

# **7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE**

Tbilisi - Georgia

March 2021



## **Introduction**

In another article, I pointed out that human beings today have made astonishing advances in technology and instrumental knowledge, to the point where they have traveled geographical and temporal distances with communication technology and planned access to other planets, but to In line with these technological advances, the development of morality and human education has not been addressed (Bahrani, 1398), but we are far behind in this regard, as in terms of war and bloodshed and violation of the rights of others, the human case is very black. In this article, I want to follow and analyze this problem in terms of underdevelopment of abstract and philosophical thinking, which seems to be the basis of educational and moral progress.

Abstract thinking can be better explained by comparing it with objective thinking. This duality was probably first introduced to psychology by Jean Piaget, who studied the issues of cognitive development in children. In a preliminary definition, with a general understanding of the explanations provided in this field, we can express the concept of objective thinking in such a way that when thinking about phenomena is done by embodying their material aspect, thinking will be objective and in cases where thinking is the physical properties of objects and phenomena Involves imagination and abstraction, the thought process becomes abstract. Obviously, abstract thinking is much more complex than objective thinking. For example, when a person is physically harmed, we pay attention to the characteristics of the things that are objectively in front of us. Thinking is an objective type, but when we want to understand the mental damage of a person who has been oppressed, or when we think about the impact of social factors on children's upbringing, we have less access to objective aspects and more help from mental and imaginative content. In these cases we are dealing with more difficult theorems and the thought process will be abstract and based on it.

The comparison of abstract thinking and objective thinking has been considered by researchers in different ways, as Tsai and Thomas (2011) studied it by examining immediate judgment as opposed to contemplative judgment; Or Forster et al. (2004) looked at the impact of time on making long-term or short-term decisions. In these comparisons objective thinking is assumed, hasty and shallow and abstract thinking is considered as deeper and more comprehensive. Even Liang and Kale (2012) have studied it in terms of cultural differences and pointed to differences of thinking habits among Westerners and East Asians, in the sense that objective thinking is more pervasive among Asian peoples.

Abstract thinking is thinking beyond the superficial aspects of phenomena and objects and is done by leaving aside the material and physical aspects, while objective thinking is formed by looking at objects and phenomena or their embodiment in the mind. It can be thought of as mind maps taken from objects and phenomena and the relationship between them, such as when we move by a paper or mental map that we have of a city to a specific geographical point in that city; here the activity of thinking is objective; but, when we think of an utopia in which people are equal in terms of human rights, thinking is an abstract ones.

Our cognition as human beings is naturally formed on the basis of our five senses, and as a result, thinking is highly dependent on these senses and what we have experienced through them. Our

# 7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE

Tbilisi - Georgia

March 2021



world is a material world, and it is what we perceive through the five senses. If we want to imagine something about which we have no mental background, we still try to use our objective experiences and visualize a form of it in our minds. This makes it easy for us to imagine that particular thing. As a child, for example, we were intimidated by a creature called Al, and we were portrayed in our minds as a stocky old woman with disheveled hair and curly stature, which terrified us. Our mind depends on our material experiences of phenomena; with an empty mind we cannot imagine a creature called "Al". An empty mind has nothing to think about. Thus, even in very abstract concepts of religions such as God or gods, there is always an aspect of objectivity in the human mind that may be derived from the highest conceivable power for a ruler with the attributes for which God is intended. In other words, in a large part of our lives we are forced and limited to objective thinking because the dominant mental framework and the world around us are the same material objects and phenomena.

Other creatures for which problem-solving ability is conceivable seem to rely on objective thinking to do so, although we do not yet know much about thinking in animals. Lizzie Rogers (1997) in her book "Minds of their own: Thinking and awareness in animals" by studying the views of scientists in this regard, emphasizes that many of them insist on animal self-awareness and for recognizing self-awareness in animals language is a necessary so that they can communicate with us to tell us about themselves. For this reason, we currently have little knowledge of thinking and self-awareness in animals. But animal intelligence research suggests that creatures such as mice to cross in mazes, or chimpanzees to solve problems rely on memory and previous experiences or mind maps. Accordingly, this level of thinking is also seen among the creatures of the lower evolutionary levels, but abstract thinking is inconceivable for them. Therefore, this difference in the level of thinking should be considered as an important aspect of human progress as the highest evolutionary level.

"Abstract thoughts can be generally defined as ideas that are self-generated and independent of stimuli, as opposed to stimulus thoughts, which are not derived perceptual information," says Damantil (2014). Beyond this definition, two specific forms of abstraction can be considered (see Ney et al., 2014). Abstract can be defined in terms of time: Abstract thoughts are those that relate to long-term goals of the past or future. Abstraction can also be defined as relational: abstract thoughts are those that focus on the relationships between representations rather than simple stimulus properties. A subset of cognitive processes in particular requires a great deal of manipulation of abstract thought, whether in a time frame or a single relationship, or both.

## Theoretical perspectives and the importance of abstract thinking

The word abstraction means to pull out and pull out, and by its nominal form, abstract thinking can be called a process of thinking in which phenomena are analyzed and studied beyond their appearances, or a meaning is inferred from them according to their nature. For example, when nature is referred to by the metaphor of generosity and generosity, in fact, the adjective generosity is generally inferred and abstracted from the fertility and fruiting of trees, fields, mountains, plains and deserts and has led to a kind of conclusion in the thought process. It is as if, apart from a simple view of nature, we have achieved a higher understanding of its nature.

# **7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE**

Tbilisi - Georgia

March 2021



"Humans have a unique ability to construct abstract concepts that have no place in the physical world," says Marcel Just, a professor of psychology at Hub University in the Dietrich College of Humanities and Social Sciences. Human ability in abstract thinking plays an essential role in scientific and intellectual progress. Unlike tangible concepts such as the hammer, abstract concepts, such as morality, have no obvious place in parts of the brain that deal with our body's perception or control (Vargas and Just, 2020).

One of the important functions of the brain is the function of executive control, which includes abilities such as text processing in working memory, response inhibition, cognitive flexibility and abstract thinking (Nejati and Ramesh, 2015, quoted by Heyder, Suchan & Daum, 2004). Abstract thinking is known as one of the high-level functions of the brain, which requires more complex than functions such as objective thinking and involves large parts of the brain, such as those with brain damage in the anterior part of the brain which it is demolished.

Piaget explains abstract thinking by examining children's development. When something is hidden from the young child's eyes, it no longer exists, because his cognition is limited to objective things and environmental stimuli, but as cognitive development progresses, the child realizes that what is hidden may still be exist. These mentally loadings in the child's memory lead to the formation of mental structures and gradually provide the basis for formal thinking so that he can understand that by deforming a piece of play dough, properties such as volume and mass remain constant. In a reasoning and deductive process based on his experiences, the child reaches the stage of abstract thinking that knows what proverbs mean in the general sense, or can imagine in his mind a creature with a human head and horse's trunk.

Inspired by Piaget (1953), Ati (1997) made systematic observations of young children at different stages of thinking and identified the relationship of functional dependence of a cognitive schema. He argues that sensory-motor experience paves the way for the development of abstract thinking, whereby young children turn real-life experiences into mental schemas and representations. This is created through states of cognitive conflict and imbalance that are digested through processes of absorption and adaptation. Assimilation refers to the use of existing knowledge to solve new problems, while adaptation refers to the situation in which a person changes or builds knowledge to meet a new challenge. Based on this idea, Ati (1990) made systematic observations of the development of children's thinking and classified them into four stages: i) progressive, ii) motor, III) symbolic representation and the relationship of functional dependence, and IV) thought. In the symbolic stage, children symbolically represent the virtual properties of objects in the immediate vicinity or from their memory. For example, children may pretend that a single piece of block is a piece of cake. In the thinking stage, the child can describe this piece of cake and explain without looking at it that it can be cut in half to share with a friend. Before this stage of thinking, the child must observe and understand that cutting a cake in half divides it in half to produce two smaller pieces, which has been identified as a functional dependency relationship. In other words, young children in this transitional phase are making the connection between objective reality and abstract (Atosuka and Tim, 2016).

# 7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE

Tbilisi - Georgia

March 2021



Glazersfeld (1989, p. 125; quoting Bagheri and Khosravi, 1378) argues that Piaget's cognitive theory is instrumentalist and that two forms of instrumentalism can be distinguished in it: first, at the sensory-motor level, where schemas of action are instruments that enable the organism to achieve its goals. He calls such instrumentalism utilitarian. The second is at the level of abstract thinking, in which operational schemas are tools that enable the organism to achieve a coherent conceptual network that is efficient in practice and thinking in terms of the organism. In contrast to the first form, this level is epistemological instrumentation.

Benjamin Bloom's (1956) theory of cognition, which classifies different levels of learning and cognition, also refers to high-level thinking that occurs in the stages of analysis, evaluation, and creation. These three levels, which are above the three basic levels (knowledge, understanding, and application), represent high-level learning and thinking.

According to construct level theory (CLT; Trope & Liberman, 2003), people experience only the here and now directly. It is impossible to experience the past and the future, other places, other people and other choices of reality. And yet, memories, plans, predictions, hopes, and unrealistic choices fill our minds, influence our emotions, and guide our choices and actions. How can we reach far away from here and now? How do we plan for the distant future, understand the views of others, and consider hypothetical reality options? Construal level theory believes that we do this by forming abstract mental instances of distant objects. Thus, although we cannot experience what is not now, we can predict the future, remember the past, imagine the reactions of others, and think about what could be. Predictions, memories, and speculations all have a mental structure distinct from direct experience. They serve to transcend the present situation and represent objects psychologically. Psychological distance is a mental experience that something, near or far, exists here and now. Psychological distance, then, is self-centered: its point of reference is itself, here and now, and the different ways in which an object can be removed from that point — in terms of time, place, social distance, and hypothetical — constitute different dimensions of distance.

The importance of abstract thinking in construal level theory has been explained through the concept of psychological distance. Trope and Liberman (2003) point to the human progress that is made by foresight: Looking even further at the psychological distance, it is worth noting that collective and individual human growth increases over longer distances. The turning points of human evolution include the development of tools that require planning for the future, the development of specific performance tools, which require hypothetical options, the development of consciousness, which made it possible to recognize distance and perspective, the development of language, the possibility of It provided larger and more complex social groups and relationships, and the domestication of animals and plants, which required a long-term perspective.

Thus, according to CLT theory, individuals travel through different psychological distances using similar mental processes. Since different distances have the same self-centered reference point, they all need to be cognitively related to each other and similarly affect and be influenced by the perceptual level. As the psychological distance increases, ideas become more abstract, and as the level of abstraction increases, so does the psychological distance of individuals. Thus perceptual levels expand and open the individual's mental horizon. Different distances should affect

# 7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE

Tbilisi - Georgia

March 2021



prediction, evaluation, and action in the same way, because these consequences are mediated by perception.

Explanations of this theory about time intervals near and far from moral behaviors and judgments have also been extended (Agrastom and Bjorkland, 2013) to the point that distant time events lead to greater moral consideration. Perceptual level theory holds that people think about abstract temporal events more abstractly and can see the bigger picture. Because values and moral principles have an abstract structure that applies to many behaviors and situations, these principles and values become more prominent and important when people pay attention to events that are chronologically distant. Distance in this theory expands the breadth of view and general attitude and high level to the phenomena.

Reflecting on the content of dreams can also give us clues about abstract thinking and how it is formed. Our minds are active and dreaming during sleep. The nature of the dream is still shrouded in mystery. But what is certain is that our dreams are shaped by the dough of daily objective experiences (Skardi and Hoffman, 2003). However, dreams are often so imaginary and beyond reality that man has long tried to interpret them and sometimes believed in the possibility of predicting the future from their content (such as the story of the Prophet Joseph's dream about a famine in Egypt), or the ancient sages attributed various symbols of the dream to ordinary life (such as dreaming of snakes, crows, running water, etc.); Even psychologists have become interested in the analysis and interpretation of dreams, as Freud and Jung interpret psychological complexes based on the content of dreams. All of this shows the mystery and dazzling complexity of dreams and the extraordinary ability of the mind to deal with this type of abstract schematic.

## Abstract thinking and critical thinking

Critical thinking is a concept close to abstract thinking that has been widely discussed in the fields of science, education and psychology. The development of this ability has been considered in educational circles since the time of Plato and has been the basis of modern Western universities (Chat Myers, 2016: p. 7). There is no general consensus on the definition of critical thinking. Chat Myers describes it in terms of logic and problem-solving skills and compares them with the following processes: 1) Problem identification and definition 2) Information gathering, 3) Preliminary conclusion, 4) Test results, and 5) Evaluation and decision making, along with fundamental logical operations (inferential reasoning, attack theorems, logical analogy, etc.) are involved. The need for training and practice to acquire critical thinking skills has been emphasized by Chat Myers (pp. 14-12). He quotes John Dewey as defining the nature of critical thinking as "suspended judgment" or "sound skepticism" and points to its qualities as "rational thinking involves the active, consistent, and careful examination of belief or knowledge." There are clear similarities between Piaget's abstract and formal thinking and what is called critical thinking, i.e. the ability to set generalities, accept new possibilities, and stop judging (Chat Myers, 2016, p. 38).

# 7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE

Tbilisi - Georgia

March 2021



## Nurture and teach abstract thinking

As stated, abstract thinking requires a higher level of processing in terms of processing level than objective thinking, and therefore more experience and skills are involved in this process. These characteristics of abstract thinking indicate that this type of thinking is seen in educated and thoughtful people and ordinary people pay less attention to it and have less benefits. In other words, this type of thinking requires cultivation, practice and skill. Since human civilization and progress in various fields of science, literature, culture, art, architecture and engineering are the products of complex mental functions and abstract thinking, cultivating this type of thinking and providing a fertile ground for the development of high-level brain functions should be on the agenda should also strive to flourish by educational systems and other related institutions and media.

First of all, we need the importance of this kind of thinking to be recognized by educational institutions in order to provide motivation and the need to cultivate it. One of the main goals of university education is to transfer students from a self-centered world based on limited personal experiences and tangible realities to a richer and more abstract world, encompassing many different values, insights, and facts. Students will not be able to think critically unless they can at least temporarily put aside their perception of reality and think of other alternative realities. As part of this process, students should be taught to disregard their immediate experiences in order to expand their intellectual abilities (Chat Myers, 2016, p. 36).

An analysis of educational systems shows that at present their main reliance is on the transfer of knowledge to pupils and students. This method does not stimulate abstract thinking and high-level work of the brain, especially in the Iranian educational system, the plague has penetrated for many years that children have to aim to cross the entrance exam barrier, and at the university level, the motivation to obtain a degree has exceeded other goals. Obviously, such conditions are not compatible with the cultivation of abstract thinking. Creativity and innovation in these systems are not stimulated and do not come at a price. Creative thinking, which is the hallmark of abstract thinking, has given way to the accumulation of material and memory, so that instead of focusing on new ideas, pupils are limited to engaging in the details that are considered for highly competitive scrutiny tests. This is similar to habit repetition and robotic memory. Education thinkers have emphasized the trainings, as Thales quotes Radmand says: "In order to create social change, educators need to rethink their role and focus their activities on teaching skills and methods that students need for independent research" (Myers, 1374, p. 7).

Other educators believe that thinking can be taught and have suggested ways to facilitate it. They believe that by providing the right conditions, it is possible to achieve this skill well. Herman believes that the goal of education should be to use all the features of the brain. What is needed is a better balance and value for all thinking abilities. We need to learn how to use these abilities and combine these abilities to think and solve problems using the whole brain.

"Research shows that fostering creativity is not a matter of increasing one's ability to score high on the IQ test, but of improving one's mental attitudes and habits and developing creative skills that have been inactive since childhood, which is hidden in a corner" Dao said."(Dao, 1976, p. 60).

# **7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE**

Tbilisi - Georgia

March 2021



In teaching abstract thinking, one of the prerequisites is knowing the level of cognitive development of the child. According to Piaget, children's cognitive development has stages and hierarchy that consists of four main stages: 1- Sensorimotor stage (birth to 2 years), 2- Preoperational stage (ages 2 to 7 years), 3- concrete operational stage (ages 7 to 11 years ), 4- Formal operational stage (ages 11 and up). Thinking begins to take shape concretely around the age of two, but around the age of 11 the children are able to do it formally or abstractly. These steps occur in a consistent order in all children and show that developmental prerequisites must be considered for teaching abstract thinking.

Abstract thinking as a skill in terms of education has been considered by researchers in the field of education, as Eric Papas says: Thinking is an art and like any other art (such as playing the piano, writing and painting), practice and at least intermediate education is necessary in learning. This fact becomes more apparent when people move away from learning and using popular "thinking tools" (such as brainstorming) and instead show that they are discovering their thinking processes and understanding how and when to use them. These inner skills are generally abstract in nature (Papas 2004).

One of the first articles to teach abstract thinking was written by Blanc (1968). According to Blank, the lack of an internal symbolic system for organizing and encoding his world is one of the weaknesses of deprived children to abstract thinking. To overcome these weaknesses and organize the child's world, he emphasizes on the following:

- A) Selective attention. Disadvantaged children are drawn almost solely to stimuli which have potent perceptual qualities (e.g., blast of a horn, a whirling disc, etc.). By encouraging the child to compare in terms of color, size and shape of objects or guiding him to internalize his new knowledge and evaluate new perceptual information with the previous system, the child overcomes this weakness.
- B) Reduction of visual dominance. Visual stimuli are particularly dominated by "perceptual magnetism" with the result that many non-visual stimuli are experienced without awareness. For example, a child may feel pieces of sponge and velvet many times and yet be unaware that these are different textures. To solve the problem, the child is encouraged to pay attention to other dimensions of stimuli.
- C) Reducing the egocentric perception. The grip of perceptual stimuli can be lessened if the child can achieve a "psychological distance" between himself and the material.
- D) Recognition of the significant characteristics of objects and events. Children in objective action passively accept situations without question (intellectual curiosity). To develop this skill, the child should be led to question the qualities of the commonplace. For example, to show why we wear boots on a winter morning, one must recognize that the boots are made of a certain material.
- E) Recognition of the tangential from the germane. With the exception of perceptually prominent features the 'young child sees all elements in a situation as having equal significance. This limitation is frequently evidenced in the child's recounting of a story where endless minutiae obscure any central theme. In attempting to overcome this, it is helpful to have the child use the motivation of the characters as a means of analyzing a story, e.g., "Why did the bird leave the nest?

# 7<sup>TH</sup> International conference ON PSYCHOLOGY OF EDUCATION SCIENCES AND LIFESTYLE

Tbilisi - Georgia

March 2021



Why did he stop to speak to all the other animals? Why wouldn't the little girl speak to the crocodile? How did the boy feel when he saw his mother?" By focusing on a main theme the child is helped to separate the tangential from the germane.

To foster this ability, it is useful to focus on properties having some personal relevance since the child frequently observes these very well; specifically, emotional states (sad, happy, worried, and the facial features associated with these), bodily states (cold, warm, hungry, thirsty, etc.), affective qualities (pretty, ugly, nice, etc.).

DeHaan, (2011) on teaching creative scientific thinking refers to two types of creativity frameworks: 1) achieving a creative insight through the idea of association that the solution suddenly comes to mind, 2) creativity as a social phenomenon that is acquired by interaction with social Knowledgeable people. DeHaan, then adds that teaching creative thinking involves creating the conditions for each of these situations in which students discuss issues with each other or seek out new solutions through extensive thought practice. He suggests the following methods: One is that the teacher raises an open-ended question and gives students a minute to think about it, then examines the features of the problem with his or her own hand and reconstructs his or her ideas and many solutions, then share the answers. The second method is that by asking a question from the teacher, students, while performing the previous steps, share their best answer with one or more people and then reach a collective answer. The third method is to think aloud based on the contents of the memory. Teacher's question is developed by two students, one explanatory and the other responsive, who repeatedly represent and clarify what the respondent says in a new way, then the teacher collects the explanatory solutions in other steps.

Otsuka and Jay (2016) in an experimental study of children aged 3 to 4 years by studying the process of intellectual development of children from concrete thinking to abstract thinking, expressed their experiences in this regard as follows: "Children should be given the opportunity to tackle the issue well. In this way, educators can provide the best environment for children to fully develop abstract thinking skills." The researchers recommend that educators wait as long as possible by exposing children to different types of exercises and equipment, and allow opportunities for children to experience concepts physically before giving instruction. The role of internal insights in this study is considered important.

## References

- Agerström, J. & Björklund , F., 2013. Why people with an eye toward the future are more moral: the role of abstract thinking. *Basic and applied social psychology*, 35:373–381, DOI: 10.1080/01973533.2013.803967 (In Persian)
- Bagheri Khosrow and Khosravi Zohreh, 1378. Piaget Developmental Epistemology. *Cognitive News*, First Year, No. 1, 40-35. (In Persian)
- Bahrani, M., 1398. Education is a neglected aspect of education. *Paper presented at the Third National Conference on Strategies for Achieving Sustainable Development in Educational Sciences and Psychology*, Tehran. <https://www.symposia.ir/RTCONF03> (In Persian)
- Blank, M., 1968. A methodology for fostering abstract thinking in deprived children. Albert Einstein College of Medicine, Bronx, N.Y. Dept. of Psychiatry. Pub Date Mar 68 Note-21p.; *Paper presented at*

**7<sup>TH</sup> International conference ON  
PSYCHOLOGY  
OF EDUCATION SCIENCES AND  
LIFESTYLE**

Tbilisi - Georgia

March 2021



*the conference on the Problems in the Teaching of Young Children," Toronto, Ontario, Canada, March, 1968. ED 026 131.*

Bloom, B., Englehart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R., 1956. Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York, NY: David McKay.

DeHaan, R. L., 2011. Teaching Creative Science Thinking. *Science*, 334 (6062), 1499-1500. doi:10.1126/science.1207918

Forster, J., Friedman, R. S. & Liberman, N., 2004. Temporal Construal Effects on Abstract and Concrete Thinking: Consequences for Insight and Creative Cognition. *Journal of Personality and Social Psychology*, 87(2), 177–189. DOI: 10.1037/0022-3514.87.2.177. Retrieved on 9/28/2020 from: <https://core.ac.uk/download/pdf/208474411.pdf>.

Liang, B. & Kale, H., 2012. Cultural differences in imagery generation: The influence of abstract versus concrete thinking. *Journal of Business Research*, 65(3), 333-339.

Schredl, M. & Hofmann, F., 2003. Continuity between waking activities and dream activities. *Consciousness and Cognition*, 12 (2), 298-308. [https://doi.org/10.1016/S1053-8100\(02\)00072-7](https://doi.org/10.1016/S1053-8100(02)00072-7) Neural Representations of Abstract Concepts: Identifying Underlying Neuro semantic Dimensions". Robert Vargas, Marcel Adam Just. *Cerebral Cortex* doi: 10.1093/cercor/bhz229

Myers Chat (1395). Teaching critical thinking, translated by Khodayar Aboli, Tehran, Samat Publications. (In Persian)

Otsuka, K. & Jay, T., 2016. Understanding and supporting block play: video observation research on preschoolers' block play to identify features associated with the development of abstract thinking. *Early Child Development and Care*, 187 (5-6), 990-1003.

Pappas, E.C. Teaching thinking and problem solving in the university curriculum: a rationale. In: Proceedings of the American Society for Engineering Education (ASEE) Southeastern Section Meeting, Auburn, Alabama, USA, 2004, Session 209.

Roger L. J., 1997. Minds of their own: Thinking and awareness in animals. Published by Western Press, A Member of the Perseus Books Group. Australia.

Trope, Y., & Liberman, N., 2003. Temporal construal. *Psychological Review*, 110, 403–421. doi:10.1037/0033-295X.110.3.403

Tsai, C. I. & Thomas, M., 2011. When Does Feeling of Fluency Matter? How Abstract and Concrete Thinking Influence Fluency Effects. *Psychological Science* 22(3), 348–354. Retrieved on 9/28/2020 from: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.909.1047&rep=rep1&type=pdf>

Umontheil, I., 2014. Development of abstract thinking during childhood and adolescence: The role of rostro lateral prefrontal cortex. *Developmental Cognitive Neuroscience*, 10, 57–76.

Vargas, R. & Just, M. A., 2020. Neural representations of abstract concepts: Identifying underlying neuro semantic dimensions .*Cerebral Cortex*, 30 (4), 2157– 2166, <https://doi.org/10.1093/cercor/bhz229>