Anticipatory Model of Constructivistic Creative Thinking

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Abstract
The Creative Thinking (CT) we can describe as ability to solve unusual problems, to create new original ideas, etc. As the study of Beresnevicius show it is possible to develop CT in young and middle adulthood. An anticipatory model of CT consists of the following parameters: flexibility, originality, fluency and elaboration. The intellectual abilities $I_{nt}[t_H]$ consist from two components: Creative abilities $C[t_H]$, and Learning contribution $L[t_H]$. The mathematical model of the intellectual abilities

$$I_{nt}[t_H] = C[t_H] + L[t_H] = \{C_{0MAX} - [t_H - T_{0H}]^2\} + k_L * t_H$$

Here C_{0MAX} is maximum creative abilities, t_H is age, k_L is learning coefficient.
Keywords: creative thinking, constructivism, anticipation, modeling

1 Introduction

The aim of the research is to develop anticipatory model of Creative Thinking (CT) based on theoretical modeling and research data.
The objectives of the research are the following:

1. To analyze data on understanding of CT.
2. To describe differences between crystallized and fluid intelligence as the model of CT.
3. To develop anticipatory model of CT based on mathematical modeling.

Hypothesis:
We assume that it is possible to develop abilities of CT in young and middle adulthood using appropriate methods of facilitation of students learning to solve unusual problems and eliminate the thinking constraints such as mental fixation founded by Gestalts.

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2 Theoretical analysis of literature concerning creativity

Understanding of CT is complicated and different. Some authors describe CT as component of Intelligence. For example Guilford describes CT as one of the factor of human Intelligence. Creativity he related with divergent thinking. According to the Guilford (1950) divergent thinking has four characteristics: flexibility, originality, fluency and elaboration. Those who are fluent can produce a great many ideas, those who are flexible can produce multiple types of ideas, those strong in originality can produce unique ideas, and those good at elaboration can take their ideas and expand upon them (Kaufman, 2005).

The concept of creativity has many attributes and is a significant factor in our lives. Creative persons are observant, express part-truths, see things as others do not, are independent in cognitive faculties, are motivated by their talent and values, can hold many ideas at once, have greater sex drive, see a complex world, and have strong egos (Thomson, 1982). Creative persons are often unpopular with teachers, find it difficult to conform within institutional settings, live with anxiety, tend to make deviant scores on personality tests, have some relationship to mental illness, are productive at self-initiated activities, and have creative encounters. It is impossible to determine the level of creative potential within an individual.

Some researchers claim that creativity is the ability to be two things: innovative and appropriate to the task at hand (Baer, 1997; Sternberg, 1999; Sternberg, Kaufman and Pretz, 2002).

Webster (1990) identifies four characteristics of the creative endeavor: 1) musical imagination; 2) model of the creative process; 3) measures of creative aptitude; and 4) the observation of creative behavior. Examines the role of technology in creativity, and contends that creative thinking can be measured.

Like a kaleidoscope, CT is the ability to rearrange pieces to form a new reality, to see connections, and to think on a global scale (Petrini, 1991). CT is available only for human beings as claim many researchers (e.g. Mrevlje, 2004).

Original and unique results or achievements, herewith consistent with social and aesthetic requirement are creativity characteristic (Botwinick, 1984).

According to Gardner (1993) there is not universal creativity: people are creative only in one or few special areas. Woolfolk (1980) claims that every special area of creativity includes conception of Invention.

Every action can be named as creative if it is done in creative way (Weisberg, 1993).

Many researchers CT understand as ability to solve problems. A creator must have abilities to give a look to the problem in unusual way, find extreme unique solutions, etc. (e.g. Hill, 2000).

According to modern research date we must not creativity correlate with one or few abilities.

Creative result depends on person, process and problem claim Urban K. (1990). According to him main creativity components are following: motivation, divergent thinking, tolerance towards laxity of knowledge, ability to complete the task, special

background and abilities, common knowledge. All these components are associated with each another.

Knowledge depreciates and sometimes becomes outdated. Therefore, creativity has to be an integral part of knowledge workers with the emergence of new business realities, emerging global market, increasing involvement of the developing nations in new areas, and development of advanced technologies (Gupta, Bhargava, 2004). Demand of creative people has gone up beyond imagination in the last decades because it is only they who could face the challenges of knowledge-based jobs. Some organizations are able to identify the hidden talent of their people and forcing them to be creative, while many not.

The concept of organizational climate for creativity is useful for explaining organizational influences on innovation. Studies have shown climate for creativity to predict scientific productivity and innovation in both university and industrial (R&D) settings (Pirola-Merlo, Mann, Shields, 2004). However, a question that has not been investigated is whether organizational climate causes performance or vice versa.

One of the more dominant theories of creativity that has emerged in the last decade has been the work of Margaret Boden (e.g. Boden 1990). In her writing she has developed important notions of personal- versus historical-creativity, which have helped to define creativity in a much more formal context. Her work, which contrasts with that of Koestler (1975) and others, defines creativity as more than just novelty-producing thought, but rather of novel exploration of and creation of mental representations (Vervaeke, 2005).

Six-trait Snowflake Model of Creativity was developed by Professor David Perkins (2005) and consists of the following steps:

1. A strong commitment to a personal aesthetic. Creators have a high tolerance for complexity, disorganization, and asymmetry. They enjoy the challenge of struggling through chaos and struggling toward a resolution and synthesis.
2. The ability to excel in finding problems. Scientists value good questions because they lead to discoveries and creative solutions, to good answers.
3. Mental mobility allows creative people to find new perspectives on and approaches to problems. Creative people have a strong tendency to think in opposites or contraries. They often think in metaphors and analogies and challenge assumptions as a matter of course.
4. A willingness to take risks and the ability to accept failure as part of the creative quest. These people also exhibit the ability to learn from their failures. By working at the edge of their competence, where the possibility of failure lurks, mental risk-takers are more likely to produce creative results.
5. Creative people not only scrutinize and judge their ideas or projects, they also seek criticism. Objectivity involves more than luck or talent; it means putting aside your ego, seeking advice from trusted colleagues, and testing your ideas.
6. The last trait is that of inner motivation. Creators are involved in an enterprise for its own sake, not for school grades or paychecks. Their catalysts are the enjoyment, satisfaction, and challenge of the work itself.

The four dimensions of the creative personality--thinking, sensing, intuition, and feeling--are described, as are the creative process (including preparation, incubation, illumination, and verification) and ways in which teachers can assess and promote creativity are described in the Wallace study (1986). Creative classroom environments and teaching methods are detailed.

Reichling (1990) defines imagination through a review of literature of music, religion, and aesthetics. Suggests that imagination precedes creativity and involves perception, intuition, thinking, and feeling.

Strategies (Jalongo, 2003) to clarify the definition of creativity include equating creativity with productive thought, differentiating the eminent creativity of geniuses and the problem-solving ability more widely distributed, and gaining a multicultural perspective on the concept. The statement emphasizes that creativity depends on talent, motivation, interest, effort, and opportunity. The statement further maintains that creativity is socially supported, culturally influenced, and collaboratively achieved.

Complex design problems require more knowledge than any one single person can possess, and the knowledge relevant to a problem is often distributed and controversial (Fischer, 2004). This asymmetry of knowledge provides the foundation for social creativity. New media that allow owners of problems to contribute to the framing and solving of complex problems can support social creativity. G. Fischer has designed, developed, and evaluated innovative new media and technologies based on a meta-design perspective. Meta-design is focused on creating socio-technical environments in which stakeholders can act as designers and active contributors in personally meaningful activities.

3 Creative thinking in ontogenesis

According to Schooler C. (1990) Intellectual flexibility is possibility to evaluate different viewpoints and potentialities and to find alternative solutions of cognitive problems.

Schaie K.W. (1990) discovers that Intellectual flexibility is correlated with better cognitive abilities in older age. Intellectual flexibility acts with other parameters of CT. For example, complex environment can necessitate Intellectual flexibility and force it (Schooler, 1990). Extreme exertion required conditions in work place and possibility to do tasks in self-dependent way could improve Intellectual flexibility. The work with lack of such possibilities has negative influence to Intellectual flexibility (Schooler, Mutalu and Gates, 1999).

Empirical data of Simonton D.K. (1988) show the growing process of creativity in many people. This process reaches its peak near 40 years old and then slowly goes down.

There are big fluctuations for individuals for many reasons. Simonton suggests changing the "age" in to "career year" conception. People who start their career later can reach their peak in older year that these who starts earlier.

The year in which people reaches their biggest creativity and productivity depend on field of their activity (Dennis, 1966; Horner, Rushton and Vernon, 1986;

Simonton, 1975, 1989). Such disparity on creative age can be explained on demand of different abilities requested in the field. One field request youthful enthusiasm, another request experience accumulated in many years.

4 Possibility to develop creative thinking

Horn J.L. (1967; 1982) and Cattell R.B. (1965) studying life span development of intelligence divided intelligence in two parts: crystallized and fluid intelligence. Crystallized intelligence contains such aptitudes as verbal thinking, problem solving based on knowledge and experience, skills and culture. Crystallized intelligence is increasing with growing. Experience of human is developing via life-span. Verbal aptitudes are even in creasing in older age. Fluid intelligence is not based on the knowledge or culture. Fluid intelligence helps us to solve new unusual problems. Fluid intelligence contains working memory, speed of thinking, understanding of space relations, so we (Beresneviciene, Beresnevicius) can describe fluid intelligence as creative thinking. In some tasks both intelligence may be used (Papalia, Camp and Feldman, 1996).

According to the Cathel and Horn date fluid intelligence is increasing gradually and reaches its peak in adolescence and in young adulthood starts to decrease, that is shown in Fig. 1 (Beresneviciene, 1996).

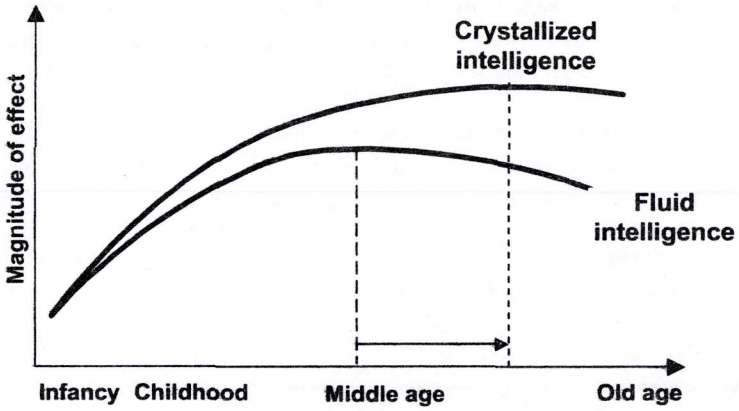

Figure 1: Development of Intelligence by Cathel and Horn

Baltes P.B. and his colleagues (1984) have proposed a Dual-process model of adult intelligence, based on Horn and Cattell's conception on fluid and crystallized intelligence. The model identifies and seeks to measure mechanics and pragmatics intellectual processes. Mechanics of intelligence is linking with working memory and are basic, physiologically determined functions of the brain. Pragmatics of intelligence

is processes involve a wide range of accumulated, culture based knowledge and skills. This dimension is similar to crystallized intelligence and depends on long term memory.

Middle-aged and older adults are likely to improve in the use of information they have garnered from education, work, and other experience. These pragmatic abilities often outweighs the brain's mechanical condition (Baltes, 1993).

The Sietle Longitudinal Study of Adult Intelligence, conducted by Schaie K.W. and his colleagues over a span of more than three decades shown that most fairly healthy adults apparently experience no significant impairment in most abilities until after age 60 (Papalia, Camp and Feldman, 1996). If they live long enough ,most people's intellectual functioning will show some decline at some point, but not in all or even most abilities. These and other findings suggest that no single measure, such as IQ, can adequately describe either age changes in individuals or age differences among props (Schaie, 1994).

Baltes P.B. (1992) describes inability to develop fluid Intelligence in older age. This position takes and Csikszentmihalyi M. He believes that the right combination of personal characteristics and encouraging environment produces creativity, and that children cannot be taught creativity.

Reed I.C. (2005) explores creativity and motivation in the second half of life. While many quantitative studies on creativity show decline with advancing age, there is some evidence that creativity may change qualitatively over time. The purpose of his study was to elucidate self-perceived changes in creativity over the life span. The participants included visual artists, both working and retired. Findings indicated that participants do not perceive a decline in creativity with age.

In summing the observation of many research data, Papalia and others (1996) conclude that research has demonstrated that it is possible for adults to improve their intellectual performance throughout the lifespan, eve in tasks involving fluid intelligence.

According to the Beresnevicius date it is possible to develop fluid intelligence in young and middle adulthood if we understand fluid Intelligence as the model of CT. The Simple transformations of the object, Time-space-value operator, Focus object, Morphological construction, Construction of the steps and other methods were used (Beresnevicius, 2004). These methods are based on visual thinking, modeling, combination of pieces of known world, free associations, mental transformations, etc.

The significant improvement of ability to generate new ideas in training groups was observed after set of training sessions.

Many researches have developed creativity improvement or problem solving methods, heuristics or algorithms.

Some methods based on heightening or expanding people's creative abilities and removing obstacles that blocks free flow of new ideas. Such methods are developed Osborn, Gordon, de Bono, etc.

Some heuristics as Attention, Consideration and Ambition is based on analysis of works of great creative authors (Wallace and Gruber, 1989). Different heuristics can be used in different fields of human activity, from games to economics. Concept of

heuristic thinking is described in the works of Wallas (1926), Polya (1957), De Groot (1965), Newell and Simon (1972), Holyoak (1990).

To achieve the goal of the task creator must have huge amount of ideas (de Bono, 1992; Shekerjian, 1990; Weisberg, 1993).

Another point of view has proponents of algorithmic method of problem solving. The founder of TRIZ (abbreviation of Russian words which we can translate as Theory of Invention) Altshuller G.S. (1973,), Horowitz G., creator of Advanced Systematic Inventive Thinking (2005) claim that it is not necessary to have many ideas and used the strong follow of thinking steps we can reach great creative solution of the very complicated problem. Thinking process in the algorithmic way not depends on abilities of creativity. All we need is to know the algorithm and to be its master.

According to the Laney's study (2005) use of metacognitive strategies, creative problem solving, and creative thinking techniques in intermediate grade writing instruction can promote students' thinking and creativity. Metacognitive strategies can help students attack the writing task in an orderly fashion.

The teaching in a way that encourages and rewards creativity can improve school performance (Sternberg, 2003). It is also argued that children can learn to make certain kinds of decisions that will enhance their creativity.

5 Anticipatory model of Creative Thinking

With the aim to create anticipatory model of CT the mathematics was used.

The intellectual abilities and creativeness is a specific property of warm-blooded organisms and the human as a procedure of thinking *e.g.* anticipatory activity. This property is of special structure of the brain – of the neocortex's virtual to create plans-projects, programs of possible actions, for anticipatory control.

The intellectual abilities $\mathbf{I_{nt}[t_H]}$ consist from two components:

- Creative abilities $\mathbf{C[t_H]}$, and
- Learning contribution $\mathbf{L[t_H]}$.

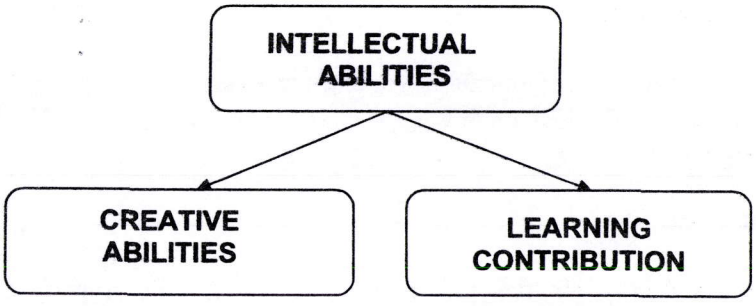

Figure 2: Intellectual abilities

The intellectual abilities as a creative and learning contribution abilities of the person, which are inseparable from abilities to anticipate changes in development with age t_H. The creativity as well as intellect it is measured by the special tests revealing ability in different situations to see of as much as possible variants of interpretations and explanations. By experimental investigations it is noticed, that creative abilities $C[t_H]$ grow with age t_H and the maximum C_{0MAX} in the period of the teenager reaches (achieves), and then falls down. The learning contribution $L[t_H]$ grow linear with rate coefficient k_L

The mathematical model of the intellectual abilities $I_{nt}[t_H]$

$$I_{nt}[t_H] = C[t_H] + L[t_H] = \{C_{0MAX} - [t_H - T_{0H}]^2\} + k_L * t_H$$

According to Cattel and Horn (1964), it is possible to find 2 kinds of intelligence: crystallized intelligence and fluid intelligence. Crystallized intelligence is developing via life span according to normal distribution, but fluid intelligence which contains creative thinking, reaches it's peak in adolescence and later is quickly decreasing. It means, that creative abilities $C[tH]$ grow with age t_H and the maximum C_{0MAX} in the period of the teenager achieves, and then falls down.

By G. Beresnevicius, D. Beresneviciene experimental study, using special training of creative thinking of middle adults, it was found that learning contribution $L[t_H]$ grow linear with rate coefficient k_L

The two mathematical models of the creative thinking $CT[t_H]$ are discussed:

$$CT_{[tH]} = C[t_H] + L[t_H] = \{C_{0MAX} - [t_H - T_{0H}]^2\} + k_L * t_H, \quad \text{or}$$

$$CT[t_H] = C[t_H] + L[t_H] = \{e * C_{0MAX} * t_H * \exp[-t_H/T_{0H}]\} + k_L * t_H,$$

Obviously, that creative thinking maximum CT_{MAX} drift in age with growing of the learning coefficient k_L, if

$$k_L > C_{0MAX}/2T_{0H} \quad \text{or} \quad k_L > 0.135\, C_{0MAX}/2T_{0H}.$$

The creative thinking maximum CT_{ntMAX} particularly drift in age if constructivist learning is usable.

Obviously, that intellectual age maximum I_{ntMAX} drift in age with growing of the learning coefficient k_L, if

$$k_L > 2T_{0H}$$

Here T_{0H} is constant of time of the exponent process.

The intellectual age maximum I_{ntMAX} particularly drift in age if constructivist learning is usable.

6 Conclusions

1. The intellectual abilities and creativeness is a specific property of warm-blooded organisms and the human as a procedure of thinking *e.g.* anticipatory activity. This property is of special structure of the brain – of the neocortex's virtual to create plans-projects, programs of possible actions, for anticipatory control.

The intellectual abilities $I_{nt}[t_H]$ consist from two components: Creative abilities $C[t_H]$, and Learning contribution $L[t_H]$.

2. Research proves the hypothesis that it is possible to develop abilities of CT in young and middle adulthood using appropriate methods.

3. Anticipatory model of CT consists of the following parameters: Creative abilities $C[t_H]$, and Learning contribution $L[t_H]$. The mathematical model of the intellectual abilities

$$I_{nt}[t_H] = C[t_H] + L[t_H] = \{C_{0MAX} - [t_H - T_{0H}]^2\} + k_L * t_H$$

Here C_{0MAX} is maximum creative abilities, t_H is age, k_L is learning coefficient.

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