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PROCESS OF PROGRAMMING STUDYING PROCESS IN THE CONTEXT OF LIMITED ATTENTION FIELD

Holovin M., Golovina N. Process of programming studying process in the context of limited attention field. The processes of programming studying in the context of peculiarities of thinking were researched. These peculiarities are conditioned by the limitation of the attention field, and structure of studying material. Attention field and consciousness are connected by the short – term memory. Three component memory model and conception about evaluation of memory field size, through the magic number of Miller were used for explanation of studying processes. The explanation of three component memory model through peculiarities of brain structure is presented. короткочасної пам'яті. In particular cyclical stimulation of limbic system was regarded as an embodiment of short - term memory. The localization of long-term memory traces and their hierarchical organization are also researched. This approach gave the possibility to connect in one model peculiarities of brain functioning, consciousness phenomenon, conceptions of education and emotional sphere of student. Original part of the research is related to graphical formalization of cognitive hierarchical scheme of long – term memory. Evolution of formation of this scheme is regarded in the article through the prism of educational strategies from general to concrete and from concrete to general.
Keywords: methodology of informatics studying, Miller magic number, attention, three component memory model, short-term memory, long-term memory, knowledge structure , studying of practical programming.

Головін М.Б., Головіна Н.М. Процес навчання програмуванню в контексті обмеженого поля уваги. Досліджувалися процеси навчання програмування в контексті особливостей мислення людини. Ці особливості обумовлені обмеженістю її поля уваги, а також структурою її знань. Поле уваги і свідомість пов'язані з короткочасною пам'яттю. Для пояснення процесів навчання в роботі використовуються трьохкомпонентна модель пам'яті і концепція оцінки розміру короткочасної пам'яті, через магічне число Міллера. Представлено пояснення механізму трикомпонентної моделі пам'яті через особливості будови мозку. Зокрема, циклічне збудження в лімбічної системи мозку розглядалося, як втілення короткочасної пам'яті. Розглядалося також ієрархічна специфіка організації довготривалої декларативної пам'яті. Цей підхід дав можливість зв'язати в одній моделі особливості функціонування мозку, феномен свідомості і поля уваги, концепції навчання, структуру знань, емоційну сферу учня. Оригінальна частина роботи стосується графічної формалізації когнітивної ієрархічної схеми в довгостроковій пам'яті. Еволюція формування цієї схеми розглядається в роботі через призму стратегій навчання від загального до конкретного і від конкретного до загального.
Ключові слова: методика інформатики, магічне число Міллера, увага, трьохкомпонентна модель пам'яті, короткочасна пам'ять, довготривала пам'ять, структура знань, вивчення практичного програмування.

Головин Н.Б., Головина Н.Н. Процесс обучения программированию в контексте ограниченного поля внимания Исследовались процессы обучения программированию в контексте особенностей мышления человека. Эти особенности обусловлены ограниченностью его поля внимания, а также структурой его знаний. Поле внимания и сознание связаны с кратковременной памятью. Для объяснения процессов обучения в работе используются трехкомпонентная модель памяти и концепция оценки размера кратковременной памяти, через магическое число Миллера. Представлено объяснение механизма трехкомпонентной модели памяти через особенности строения мозга. В частности, циклическое возбуждения в лимбической системе мозга рассматривалось, как воплощение кратковременной памяти. Рассматривалось также иерархическая специфика организации долговременной декларативной памяти. Этот подход дал возможность связать в одной модели особенности функционирования мозга, феномен сознания и поля внимания, концепции обучения, структуру знаний, эмоциональную сферу ученика. Оригинальная часть роботы касается графический формализации когнитивной иерархической схемы в долговременной памяти. Эволюция формирования этой схемы рассматривается в работе через призму стратегий обучения от общего к конкретному и от конкретного к общему.
Ключевые слова: методика информатики, магическое число Миллера, внимание, трехкомпонентная модель памяти, кратковременная память, долговременная память, структура знаний, изучение практического программирования.

Problem formulation

Attention field of a human has a limited amount of conceptual units, which he can simultaneously manipulate. This limitation puts a mark on the whole process of his thinking. Studying, as a basic part of intellectual activity process also has a specificity, which is connected with a limited field of attention. Let's examine the peculiarities of scientific activities in the context of these limitations.

The problem of developing new teaching methods and improving old is that pedagogy and teaching methods, as a science, don't study the human's brain and the mechanisms of cognitive processes. There is a problem of presenting the mechanism of attention switching, that interacts in the educational process with knowledge structure. Also, it's interesting to pay

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attention to the structure of knowledge in the process of its formation. These mechanisms, presented in the generalized form, can give the basis for the improvement of methods of traditional and automatised learning. Cognitive psychology formed conceptual vision of cognitive processes, that can be succesfully used in various developments in pedagogy and methodology of education.

Analysis of last researches and publications

In the famous work of Miller (1956) "Magic number seven, plus or minus two" was shown that the amount of notions, which person can manipulate in the field of attention is 7±2 [1]. Process of remembering is conceptually well described by the three-component memory model [2]. In the cognitive psychology it's assumed that educational actions gradually form the reflection of educational object – its cognitive scheme, in the long - term declarative memory. This scheme is perceived only in parts. It's formed in the process of repeated multiple times attention switch. Each cognitive structure is a modification of the previous one [3, 4]. The cognitive structures evolutionize in the process of their differentiation [5], and as a result they are often forming hierarchicl structures.

The construction of teaching methods, which are based on mechanisms of cognitive psychology **is actual, but unresolved problem**. Cognitive psychology does not give direct recommendations concerning the learning process. There is a necessity to adopt the doctrines of psychology to the teaching methods. Programming is an especially convenient area of research in the context of the studying process. Here, the study material is strictly formalized, interconnected and structured. The structure of the material has the refined hierarchical type. The dynamics of the educational process can be represented as detailed of known information.

The aim of this work is to examine education through the prism of three-component learning memory model. On this basis the following binding must be realized: the functioning of the brain, the phenomenon of consciousness and fields of attention, learning concepts, knowledge structure, emotional sphere of the student. The objective of this work is also to formalize mental representations of the person, in the process of programming, in the form of graphic charts and analysis of the evolution of the formation of these cognitive circuits.

The main research

Three component memory model includes sensory, short-term and long term memory (Fig.1.). Short-term memory in this model is associated with the field of memory. Reasoning of studying processes is made, based on this model.

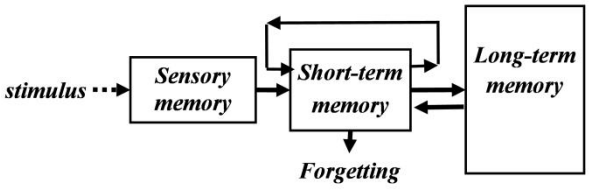

Fig.1 Three-component memory model

Process of remembering of information (studying) in the 3 component memory model is made in the following way. Information from the external environment gets firstly to the specific modal sensory registers of iconic (vision) and echoic memory (hearing), where it is stored for nearly a second in the form of physical stimulation trace. We will ignore the perception through the sensors like touch, smell and taste in the context of informatics. After going through sensory memory information is transferred to short-term storage place, with transcoding into verbally-acoustic form. If the information is not transcoded, because the person doesn't have relevant template for its classification and comparison with relevant words, than in several seconds the information is lost. For example student does not see in the text the program cycle, because he doesn't know how relevant operator looks like, and how the operator is structurally designed: does not know where starts and finishes its operation, doesn't imagine structural block-diagram of its functioning.

Remembering in the long-term memory on Fig 1. is represented by an arrow, which links short-term and long-term memory. Portion of new information easily goes through short-term memory and is

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accumulated in the long term memory, if this portion of information fits into short-term memory and complements the structure of knowledge, which was created at the moment of recognition. For example the algorithm "sorting by searching for maximum" is easily understood, if before algorithm "searching for maximum" was assimilated. If conformity between new portion and already existing structure of knowledge is not reached, then new information can temporary stay in the short-term memory, by using verbal loop – cyclic spellings of the words (notions). Than the search of conformity between information in short-term and long term memory is made. If the conformity is reached than the portion of information is included into long-term memory.

In the short-term memory the attention and consciousness are incarnated. The material, which person recognizes, during the period of studying is always limited by the field of studies. Probably because of this in the language there are words of different stage of generalization and the possibility of scaling of notions in the process of studying abstract-logical intellectual actions. In this way the words "search for maximum" unfold during its program realization as a program fragment, that includes cycle, branching and checking of condition and two conferments. Even bigger block is associated with the word "sorting", because the first algorithm is a part of second.

Long-term memory accumulates information for an uncertain tim. Every portion of new material, that comes to long-term memory is transformed depending on the existing knowledge. Some part of information can quite precisely be saved during dozens of years, for example definitions, theorems, poems, etc. Part of information, which is used rarely "dissapeares" (goes to the subconsciousness). Long-term memory of a student is usually partly structured (organized) in some knowledge, and part of it represents fragments, which are different and not connected to each other. Those fragments can be accessible, but they are not making the whole picture. The process of studying is a process if differentiation of existing knowledge [5].

Problem definition

The narrowness of attention field puts a trace on the order of all studying processes. Development of programming techniques is straightly connected with specificity of abstract-logical thinking. Programming technologists empirically found method of downward step by step specification and module programming [6, 7] in which in refined shape the abstract-logical thinking is reflected and programming intellectual actions in the context of limited field of attention are optimized.

Three component memory model allows: to understand some important mechanisms for methodology of teaching, and basing on it to monitor field of attention and to support the process of solving of algorithmic tasks in context of the nearest perspective: one inductive step (generalizing) and one deductive step (specification). In the case of inductive action this activity should finish by editing of current program fragment and its checking. The amount of conceptual units, which students manipulate, doesn't have to overstate magic Miller number - 7. Complex of conceptual units should make logically finished construction.

In the context of studying practical programming the moment of excretion and recognition in the program body of program fragment, in which some logically finished amount of words is excreted and compared with single conceptual unit, which generalizes the activity of program fragment, that is considered.

In the context of studying programming the most actual are hierarchies and sequences. Sequences are reflected in the following: the program is a text, written sequentially from left to right and from top to bottom. From the other side this text has a logical connections, which are recognized as hierarchical construction. The process of practical-studying programming illustrates well the forming of hierarchical and sequential structure. It's understandable that all hierarchical construction of program (in all details), that is formed in declarative long-term memory and cannot be perceived at once: during the one session of memory concentration. Studying programs from 10 to more operators are meant. During several sessions of memory concentration , which are connected with each other it is possible to cover study program of several dozens of operators. The amount of professional programs is much bigger and can be comprehended only by transferring attention many times.

The original approach to understanding of programming learning

For example, on Fig. 2 very simple study program on Pascal language is shown. The program includes 16 operators in which sorting of letters in the line is made. Every operator is responsible for separate standard action in the program. Operators in the program are connected between each other by hierarchical superstructure, which is situated in the big triangle, which is marked by dotted line.

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The circles, connected to each other mark conceptual constructions. In the toned triangles are shown the logically completed constructions, each of which can be covered during the one session of concentration of the field of attention. These triangles are named the constructs. It is seen that the creation of this program needs the solution of many intermediary tasks: the search of bigger between 2(if), exchange of indicators between two elements of the line (ob), single search of the maximum in the line (mx), sorting in the line (sr). The goal of the program is to realize text sorting in the file. To realize that it is necessary to solve extra tasks: downloading (zv) and saving of the file (zb).

Information, that is situated in the long term memory can be recognized only in small portions, the size of which is correlated with the size of short-term memory. The concentration of memory on one or other aspects of activity raises the attention in the short-term memory. This process can be named remembering.

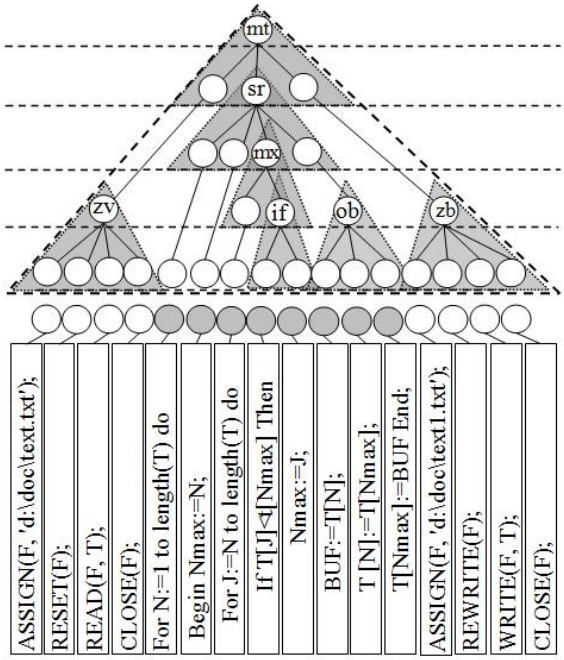

Fig.2 Simple study program and its cognitive structure

In relation to the presented above while studying task of programming it's possible to say the following. Integral mental reflection of the program, which covers all conceptual construction (the triangle is marked by dotted line) is formed in the long-term memory and is never realized fully in all details in the same time. Forming and awareness of the work mechanism is made in portions. Each portion can be covered by the field of attention. These portions are thought over in the short-term memory. It is understandable that thinking in the limits of construct mt is the thinking about the whole program in the most general treats and thinking in the limits of construct if or ob is maximally concretized.

Evolution of formation in the long-term declarative memory of the cognitive structure of the typical educational programming object, taking into account the attention are presented in the research [8].

On Fig.1 long term remembering is marked by the arrow from long term to long term memory. Memory is associated, because visual image can cause remembering of some word and vice versa.

Methodological aspect of teaching informatics in the context of views about short-term memory, needs the support of students during the process of solving of some additional tasks, which correspond to some constructs. Aspect of teaching is connected to long-term memory and needs methodological and diagnostic development, that support the creation in the declarative long term memory holistic hierarchical structures, which are the reflection of connections between separate constructions and connections between them. Moving between the constructs from up to down and from down to up are realized via refined abstract-logical thinking, that includes deductive and inductive activities, analysis, synthesis, abstraction, concretization and generalization. Effective forming of skills, abstract-logical,

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causal intellectual activities in the process of learning informatics is very important and has big impact on general education and professional preparation. The hierarchy of cognitive structure of educational object is also mentioned in the research [9]. The last is important for the development of methodical approaches in education. The knowledge of structural organization of scientific material helps to optimize the process of education through the methodological means.

According to author views, represented model allows to explain uniformly – to homogenize big amount of memory phenomena, attention, appreciation and also pedagogical and methodological aspects of learning. Methodological consequences of work analyze of 3 component memory model in the sphere of informatics learning are especially interesting, because the represented model explains strict casualness of practical studying programming and abstract logical character of cognitive actions, and also this model gives the possibility to form conceptual methodological approaches to studying processes.

Neuro-cognitive proof to the study approach

Considering all spectrums of attractive moments there is one question, that is necessary to solve, before building methodological basement. This is a question about effectiveness of this model, how it responds neuro-cognitive peculiarities of brain structure. The reply to this question can be found in the works of Ivanitskij [10].

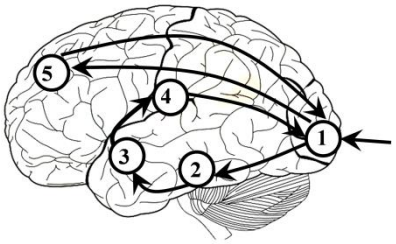

Fig.3 The consolidation of new information into long-term memory - associative cortex.
1.Projective visual cortex; 2.Associative temporal lobe; 3. Hippocamp; 4. Thalamus; 5 Frontal lobe

Short term memory in the mentioned works is regarded as circular motion excitation by system limbic system of brain, which includes projection and associative neocortex rind and some parts of middle brain . Short-term memory is not for long-term information saving. Loss of information from short-term memory is caused by fading excitation or displacement of one excitation by the other one, which is responsible for other field of attention.

Long-term declarative memory is connected with associated rind of medial sectors of temporal area of the cerebral hemispheres. Remembering in the long-term memory is realized via creation of neural connections in the associative brain rind. For realization of these connections there is a necessity of the long term excitation of one modality, which goes through appropriate temporal cortex area. The last is provided via many times repeating of information. Repeating of information several times renew neural connections and makes better the process of remembering.

Modally specific hearing and visual images are situated in associated secondary zones. In the tertiary zones the connection between modally specific images of different modality is realized. For example between a word and visual image.

For teaching it is very important to know that the components of the limbic system are responsible not only for short-term memory, attention and consciousness, but also for emotional state of person. It puts some limitations on teaching. Let's regard in more detail, in this context the processes of cyclic excitation, which is responsible for short-term memory.

Signals from sensation organs come to projection rind , then rind comes to associative rind – inferior temporal for visual stimuli (17,18 zones, hereinafter author mean Brodmann zones). There the information is compared to the standard and is recognized. Also the transcoding of information into verbal acoustic form 37.

Then excitation goes to entorial rind, which is situated on the internal part of the surface of the cortex temporal lobe (28). This rind plays the role of connector during the exchange of information between associated areas of neocortex and hippocampus.

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Then impulses get to hippocampus. After that excitations move to motivation centers of diencephalon – thalamus and hypothalamus. Here emotional attitude to perceived information is formed. It's in hypothalamus the importance of signal for the needs of the organism is determined.

From there the excitations come back by the system of diffuse projections to the brain rind, including the zones of primary projections. The last instance is the same as primary. Excitation signal gets in these conditions the closed and cycled character. Thanks to return excited nerve impulses, that come from motivational centers of brain overlap in the projection rind on the traces of sensory excitation. This cycle, the duration of which is nearly 150 ms got the name "circle of feelings". In 100 ms after starting of the process of cycle excitation appear also the connections between projection and frontal cortex. Frontal cortex provides the control of activities and their planning [8].

Let's regard in more details the influence on emotional states of different parts of midbrain, in the context of studying processes (Fig.3).

Thalamus is responsible for the primary processing, transition and redistribution of information on the way from the sensors to the rind of cerebrum (smell is an exception). In thalamus there are 4 main cores, which are responsible for visual, auditory and tactile information and the feeling of harmony and balance. Thalamus plays also an important role in remembering. Also damaging of thalamus leads antiretrograd amnesia – moving of information from short-term to long-term memory.

Hypothalamus is situated under thalamus and defines the significance of signal for different needs of organism. Hypothalamus creates together with hypophysis a single functional complex, in which first one plays regulatory role and the other one effectory role. Hypothalamus supports organism in the limits of adaptive and homeostatic parameters, necessary for life support. It is responsible for thermoregulation, regulation of breathing, regulation of sleeping cycle, quenching of hunger, thirstiness and sexual attraction. Unbalance of these parameters is the strongest motivational and behavioral factor. Hypothalamus is also called "stress center". Its unbalance can destroy any studying process.

Amygdala is connected by nerve connections to hypothalamus and is responsible for the decision to attack or to run away, swallow or not and many other. Amygdala gives fast precognitive, affective evaluation of situation from the safety of life point of view. Amygdala takes part in forming negative (fear) and positive emotions (pleasure). That is why excitation, which are caused by aggression or fear influence studies a lot.

Hippocampus, "sea horse" is made up of 2 long structures, which are connected inside temporal lobes of the brain. Hippocampus allocates and keeps in the flow of external stimulus the important information, making a function of short-term memory manager. It takes part in coding the environment around us (spatial memory). In this way hippocampus transfer information to long-term memory. If it is damaged the syndrome of Korsakov appears, when a sick person loses short-term memory and keeps only long term memory.

Analysis of the model gives the following conceptual conclusions concerning the lessons.

Conclusion

1. Scalability concepts are the specific response on limitation of attention field during the thinking process. Abstract-logical thinking, as a phenomenon, is realized by various concepts with different ranges of generality. It is reflected on computer science seminars and lectures.

2. During the process of solving programming educational tasks, problem must be divided into logical subtasks, first, each of them are solved separately and, then the solutions are combined. Similarly, educational material on the lecture is divided into logical small parts. The size of new material in every part is not bigger than 7±2 (Miller`s number). Overloading of short term memory leads to the loss of certain elements from new material. Every part has intermediate conclusion. These conclusion combinations generate conclusions at the end of lecture.

3. Conceptual structure of the programming task solution, or the one, that is relevant to new lecture material should be hierarchically structured. Hierarchical structure means connected parts of solution or lecture. Moving in such hierarchical structure, during the lecture or during the process of solving problem is available in two ways: in strategy from general to concrete or from concrete to general.

4. The strategy of program creation from general to concrete requires step by step downward detailed algorithm. On every stage the size of part is not bigger than Miller`s number. In strategy from general to concrete, each new material part starts from conceptual position which is explained in mode of specification and application. At the end of the lecture or seminar information is finished by conclusions again.

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5. Strategy from concrete to general on educational programming practice is embodied in the methodology of modular programming. This strategy from general to concrete creates general conclusion at the end of logical development and this conclusions can be logical ending of the lecture or seminar.

6. The formalization of the knowledge structure in a hierarchical structure opens the way to modeling representation of processes of thinking and learning. Mainly it concerns: software objects, classification of software and hardware computer technologies, databases, network Internet structures, schematic realization of the hardware equipment, software objects menu, etc.

7. In the process of teaching it is necessary to repeat several times new materials, which is good connected with previous material. For the creation of new neural connections the time is needed . In addition formation of new connections should be based on already formed neural structures. Any information can be completely new, each part is a modification of what we already have in our memory.

8. Hippocampus, amygdale, thalamus and hypothalamus are parts of limbic system and midbrain. They are responsible for the consolidation of new material into long-term memory, through short-term memory and for sensitive sphere. So information in short-term memory can be lost when you change your mood on the lecture. Attention focusing on abstract informatics themes cannot be achieved in case of: thirst, hunger, cold, fear, self-aggression, sexual arousal. However, low emotional background on the lecture creates a weak motivation to study new material and does not allow creating long circle excitations determination of modality to learn information in long-term memory.

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