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Formation of the primary school pupils' computing competency

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Abstract. Skvortsova S.A. Formation of the primary school pupils' computing competency. The member countries of the DeSeCo recognised the computing competency as a key one, which is necessary for effective life in the modern world. The results of the all-Ukrainian monitoring according to the academic results of primary school pupils (of the 5-th grade) have stated the urgency of searching the effective methods of forming the computing competency. Computing competency is one of the components of the subject mathematical competency. The internal reserve of a computing competency is a computing competence, the basis of which form knowledge of computing techniques and a full computing skill that is characterized by accuracy, rationality, generalization, automatism and strength. Thus, the article gives the definition of a computing method, a computing skill and its characteristics; presents the classification of calculation methods based on the theoretical framework. A computing competency is the result of mastering a computing skill and provides for mastering computing competences at the levels of analysis, synthesis, verification and assessment in accordance with the B. Bloom's taxonomy. Methods of forming a computing competency implements M. Bantova's system of formation of the computing skills and were worked out after P. Galperin's theory of gradual development of mental acts and concepts. According to P. Galperin's theory the act, before becoming a mental one, passes a number of transitional stages – from performing an act in a material or materialized form, to performing an act in a verbal form and, in the end – in the mental form. At the stage of acquaintance with M. Bantova's calculation methods the stages of a motivation creation, a preliminary review with the act, a material or materialized act by P.Galperin are implemented. Consolidation and formation of a computing skill after M. Bantova are implemented through the stages of a loud speech, an external speech and a mental performance of an act.

***Keywords*:** *key competency, computing competency, computing skill, methods of forming a computing skill.*

Since the 1990-s the search for approaches to definition and selection of key competencies has started. In 1996 at the Symposium in Bern (Switzerland) W. Hutmacher in his report "Key competences for Europe" among the key competences defined those ones related to life in a multicultural society [3, p. 11]. During 1997–2003-rd 12 member countries of the OECD participated in the project "Definition and Selection of Competencies" and in 2001 presented their reports. These reports show that all the countries have defined literacy/intellectual and applied knowledge as key competencies: the ability to read, to write, to speak, to listen, to understand, to count; in a broader sense, this is knowledge of Mathematics, ability to operate information, critical thinking, reflection, computer literacy [5, p. 21 - 22].

Thus, a computing competency is recognized by all member countries of the DeSeCo as a key one. It should be noted that all-Ukrainian monitoring (2013) of the quality of General secondary education according to the academic results of primary school pupils (of the 5-th grade) has stated the urgency of formation of Ukrainian pupils' computing competency. So, the most of the frequent pupils' mistakes are the mistakes in calculations, primary school pupils had the greatest difficulties with written division by two-digit number; the cases of outside the table division of round numbers in round number; some pupils mastered the multiplication tables not well enough.

The problem of formation of key and subject competences is currently in the spotlight of scientists of the National Academy of pedagogical Sciences of Ukraine. The theory of educational competences and competencies is justified in the works of such scientists as N. Bibik, S. Bondar, O. Savchenko, S. Trubacheva and others. Methodological aspects of the problem are disclosed in the publications of such scientists: T. Baybara, M. Vashulenko, I. Gudzyk, N. Lystopad, O. Onoprienko, K. Ponomareva. The analysis of the category "Mathematical subject competency" is based on the understanding of the generic terms and their essential features. In the CIS the concepts of "competence" and "competency" have mostly different meanings. Thus, the Ukrainian National Framework of Qualifications considers competency as an individual's ability to perform a certain type of activity, which is expressed through knowledge, understanding, skills, values and other personal qualities that identity an individual after finishing school [9]. Competences are defined as a socially significant result of education, as a basis, an internal reserve of s competency. Basis of competences are knowledge, skills and experience. Thus, competence is treated as a socially recognized level of knowledge, skills and relations in a particular field of human activity [9].

The American and European scientists use the terms "competence"/"competency" (eng.); "kompetenz" (germ.) in their researches. Foreign scientists do not distinguish the concepts of "competence" and "competency". The Oxford English dictionary (the 7th edition) reveals this concept ("competence") as "the ability to perform something successfully or effectively" [2, p. 307]. At the same time, T.Hyland determines "competency" as "the ability to perform specific activities according to the given standard" [4, p. 487]. In his turn, M. Mudler defines "competency" as "a person's ability to get certain achievements" [1, p. 523]. Thus, our analysis of scientific works of American and European researchers has shown that at the present stage of development of competence-based approach, scientists have not yet come to common interpretations of this concept. So, the majority of foreign studies, which have appeared over the last 5-7 years, interprets the concept of "competence" as the ability and willingness to mobilize all the knowledge and resources required to perform a task at a high level, adequate to a particular situation.

Pupil's subject mathematical competency is a complex personal formation, which is manifested in the various circumstances of life as the ability to actualize, to integrate and to apply the activity experience obtained in the process of studying and personal qualities in order to achieve a certain result. The basis for the formation of competency is mastering the subject competences - regu-

latory fixed learning outcomes that cover knowledge, abilities, skills, ways of activity and expressions of emotional atitudes.

Subject competences are formed in the process of mastering by students of the content of the subject, in particular, Mathematics. Thus, they are considered as a socially fixed result of education, presented in the State Standard of General education ("the Content of education" and "State requirements for the academic achievements of pupils"), and specified in the training programmes (in the columns of tables "Contents of educational material" and "State requirements for the level of General education of pupils") [10].

The New curriculum in Mathematics for 1-4-th grades of Ukrainian secondary educational institutions defined the basic task of teaching Mathematics, which consists in forming subject mathematical competences – computing, informationally graphical, logic, geometric and algebraic. Subject competences are the structural elements of the content of mathematical education. Their basis form knowledge, abilities, skills, methods of activity, which are acquired by students in the learning process. The result of mastering the subject competences is the pupils' mathematical competency. In the context of primary education subject mathematical competency is considered as an ability of a pupil to actualize, to integrate and to apply acquired knowledge, skills and ways of activity in specific life or educational problem conditions and circumstances [8].

The basis of a computing component of mathematical competency forms the readiness of a pupil to apply computing abilities and skills in practical situations [10]. Since a computing competence is formed within the subject mathematical competency in primary school, so let us focus on its formation at primary school pupils.

The goal of the paper is to define the approaches to the formation of a computing competency of primary school pupils.

We emphasize that a computing competency is one of the components of the subject mathematical competency, its internal reserve is a computing competence. Computing competence, at first, acts as a socially significant result of training. The basis of a computing competence is a computing skill. Therefore, considering the problem of formation at primary school pupils of a computing competency, we should first of all refer to the Russian scientists' worksa on the problem of formation of computing skills.

The majority of Russian and Ukrainian methodists (S. Volkov, M. Budma-Goryayeva, L. Dashevska, V. Eliseev, N. Istomina, M. Moro, N. Piyadin, G. Shmyreva, and others) consider the problem of forming of computing skills in terms of diversity of calculation exercises. Contents of certain ways of calculation are available in the works of M. Bantova, G. Beltyukova, N. Korsunska, G. Martynova, N. Nikitina, N. Rudovska, S. Skvortsova, T. Shevchenko. The system of formation of computing skills of younger schoolchildren developed by M. Bantonova [6], defines the essence of a computing method and a computing skill, describes current computing skills, and proposes a methodology of its formation.

Computing skill is the highest degree of mastery of the techniques of calculation. To master a computing skill means for each individual case to know what operations and in what order should be done to get the result of arithmetic operations, and to carry out these operations fast enough.

The method of calculation is a system of operations to be done for the act to reach its goal. It is the project basis of the action. Thus, methods of calculations on numbers consist of a series of successive operations (system of operations), that provide for finding the answer of an arithmetic act on these numbers. The choice of the operation in each method is defined by those theoretical sets that are used as its theoretical basis.

Full computer skill (after M. Bantova) is characterized by accuracy, awareness, rationality, generalization, automation and strength. These properties of computing skills relate to the characteristics of mastering a mental act by P. Galperin, who refers a degree of generalization and a degree of assimilation (automation, easiness etc) to the primary parametres of action, and strength, intelligence, awareness – to the secondary parameters of action. *Accuracy* means that a pupil selects and performs successfully the operations that form a method, and consequently finds the correct result of an arithmetic operation on these numbers. *Awareness* means that a pupil understands the knowledge that form the basis for the selected operations and the order of their execution; awareness is manifested in the fact that a pupil is able to comment on the actions at any moment and the reason why the problem can be solved in such a way. *Rationality* means that a pupil, under specific conditions, selects those of possible operations that are easier and faster and lead to the result of an arithmetic operation. It is clear that the given quality of a computing skill manifests itself only when there are different techniques of calculation for the case, and a pupil, using a variety of knowledge, can construct several techniques and choose the most rational ones. As we can see, rationality is closely linked with awareness of a computing skill. *Generalization* – a pupil can apply a calculation method in a large number of cases, he/she is able to transfer a calculation method to the new cases. Generalization like rationality is linked with awareness of a computing skill, because only the theoretical basis for a calculation method will be common to various cases. *Automation* – a pupil selects and performs the operations quickly and in a collapsed form, but can always return to the explanation of the choice of a system of operations. *Strength* – a pupil remembers the formed computing skills for a long time.

The theoretical basis of the calculation methods is either a specific content of arithmetic operations, or properties of arithmetic operations, or communications between the components and the results of arithmetic operations, or question numbering, or dependence of the results of arithmetic operations on a change of at least one component, or rules. The theoretical basis of the method form the basis of the calculation methods' classification of M. Bantova, who allocates 6 classes of methods. We agree with the classification of M. Bantova in general, however, we consider the content of groups of calculation methods of each class somewhat differently.

Methods, the theoretical basis of which are a question of numbering numbers. These are the methods of addition and subtraction of a number 1, methods of addition and subtraction on the basis of the decimal composition of

numbers, methods of addition and subtraction, multiplication and division of round numbers by enlarging bit units. For example,

$$50 + 30 = 5 \text{ dozen} + 3 \text{ dozen} = 8 \text{ dozen} = 80.$$

Methods, the theoretical basis of which are the specific meaning of arithmetic operations. These are the methods of addition or subtraction within 10 based on the number composition; tabular methods of multiplication and division. For example, multiplication can be replaced by addition of identical numbers. Therefore, to calculate the multiplication, it is enough to replace the multiplication by addition (6·3=6+6+6=18).

Methods, the theoretical basis of which are the relationships between arithmetic operations. These are the subtraction methods based on the relationships between the arithmetic operations of addition, subtraction and division based on the relationships between multiplication and division:

For example:

$$9 - 6 = 3 + 6 - 6 = 3 \qquad 16 : 8 = (2 \cdot 8) : 8 = 2$$

$3 + 6$ $\qquad$ $2 \cdot 8$

Methods, the theoretical basis of which are the properties of arithmetic operations. Thus, adding a more number to a less one within 10, it is convenient to swap components, on the basis of a resettable property of addition

$$(3 + 7 = 7 + 3 = 10).$$

And multiplying the two-syllable number in monosyllable one the distributive law of multiplication with respect to addition is applied:

$$24^* 4 = (20 + 4) * 4 = 20^* 4 + 4^*4 = 80 + 16 = 96.$$

Methods, the theoretical basis of which are the rules. These include methods of addition and subtraction of 0, subtraction of equal numbers, methods of multiplication and division of zero on the number, multiplication of the number 1 or 0, division the number by 1, equal division of numbers.

Methods, the theoretical basis of which are the dependence of the results of arithmetic operations on change of one component. These are the rounding methods in the process of addition and subtraction of numbers

$$(46 + 19 = 46 + 20 - 1 = 66 - 1 = 65)$$

and methods of multiplication and division on 5, 25, 50, 250, 125, 500

$$(36 * 5 = 36 * 10 : 2 = 360 : 2 = 180).$$

In detail the content of calculation methods within 10, 100, 1000 and polysyllabic numbers is presented in the author's paper [7].

Thus, the basis of a computing competency of primary school pupils is a full-fledged computing skill, which is characterized by all the defined characteristics and is based on the knowledge of different calculation methods. Therefore, to form a computing competency it is appropriate to acquaint the pupils with a variety of calculation methods and to form abilities of their application after P. Galperin's theory of gradual processing of action.

M. Bantova defined the stages of mastering a computing method: I – preparation, II - acquaintance with the calculation method and III - consolidation, formation of a computing skill [6]. After analysing the content of these stages we concluded that the II-nd and the III-rd stages can fully take into account the successive stages of the formation of a mental action by P. Galperin such as: creating a motivation and a preliminary review of the action; implementation of an action in a material or materialized form; performing an action in a verbal form, in the form of internal speech and in the mental form [11]. It is the theory of gradual formation of mental actions and concepts that describes the psychological mechanism of the transformation of external material actions into the inner mental ones that provides the opportunity to design a methodology of the formation of a computing competency by the implementation of each of these stages.

Based on the fact that mathematical operations are complex by their structure, and including requirements for the process of formation of mental actions, that provide high efficiency of learning abilities and skills by L. Friedman, it is expedient to operate all the components of the calculation method at the preparation stage [12]. It can be introducing pupils to theoretical basis of a method and checking their knowledge. It can also be a working out of certain steps of a calculation method (CSCM).

At the stage of introducing pupils to a calculation method, it is necessary to provide the algorithm of a new action in a finished form and to focus on its understanding, or to create a problem, the solution of which will be the opening of the new way of activity. Thus, the motivation of pupils' teaching and learning and a preliminary review of the action takes place. Obviously, in order to learn how to apply a method of calculation, pupils pass the stages of the execution of actions in the material (with objects or their substitutes) and in materialized (with diagrams and tables) forms gradually. Therefore, a teacher should provide in advance a visual representation of the content of a calculation method (CCM) in the form of a remembrance or a calculation scheme. At this stage, pupils perform an action with a certain degree of independence, as it is directed by visual support in the form of a remembrance or a calculation scheme and is guided by a teacher. The goal of this phase is to assimilate the sequence of operations that compose a calculation method.

At the stage of consolidation and formation of a computing skill by M. Bantova the action is performed with the comment. Thus, the stage of a loud speech by P. Galperin is implemented. At the beginning of this stage, remembrances and calculation schemes are still present, but later on pupils do not pay much attention to them.

At the first two stages (a preliminary review of the action and a material or materialized action) the requirement to a detailed action is implemented. It was formulated by L. Friedman who insisted on taking records and pronouncing all action's elements. At the next stage, the action begins to reduce, pupils write down only basic operations and pronounce the auxiliary ones. Finally, pronouncing of the auxiliary operations becomes redundant, meanwhile they sound in the consciousness, but not pronounced. If a pupil names only basic operations and performs a shortened record of solving, it means that the

action acquired a form of an external speech. At the mental stage the action is further reduced and is executed according to a formula. The correctness and increase the speed of solving such tasks indicate on pupil's acquisition of a mental form of performing an action. M. Bantova allocates 4 stages of formation of a computing skill, the content of which fully corresponds to the stages of P. Galperin: loud speech, external speech and mental speech.

At each stage of action's assimilation (after P. Galperin) a teacher, through creating a system of educational tasks, should provide for a proper form of the act's execution (material, materialized, in the form of a loud speech, in the form of an external speech, in the form of a mental speech), consider a level of the action's generalization during the execution of individual tasks (fully deployed action or partially reduced one or automated one), design the dynamics of the action's processing by the pupils of different typological groups (consider the promotion stages of actions' mastering by the pupils with different levels of educational opportunities).

Thus, the formation of a computing competency cannot be limited only to training exercises or computing equipment. It is necessary to teach pupils a variety of calculation methods and to form skills of their application. After working out certain calculation methods, the formation of a computing skill takes place that is characterized by all of the listed properties: accuracy, generalization, rationality etc.

Methodology of forming a computing competency should be based on the system of formation of computing skills after M. Bantova and implement the steps of action's assimilation after P. Galperin. If we compare these positions with the levels of competences' assimilation in accordance with Bloom's taxonomy, at the stage of motivation, a preliminary review of the action and an action's execution in a material or materialized form a competence is assimilated at the level of knowledge; at the stage of a loud speech – at the level of understanding; at the stage of an external speech or of a mental stage – at the level of application. The level of analysis, synthesis, verification and assessment characterizes a formed computing skill. The methodology of forming a computing skill for certain calculation cases is presented in detail in the author's paper [7].

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Скворцова С.А. Формирование вычислительной компетентности учащихся начальной школы

Аннотация. Страны-члены DeSeCo признали вычислительную компетентность как ключевую, которая необходима для эффективного жизни в современном мире. Результаты всеукраинского мониторинга в соответствии с академическими результатами учащихся начальной школы подтвердили актуальность поиска эффективных методов формирования вычислительной компетентности. В статье представлены определение способа вычисления, вычислительного навыка и его характеристики; классификация методов расчета.

***Ключевые слова**: ключевые компетентности, вычислительная компетентность, навыки вычисления, методы формирования вычислительных навыков*