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TRAINING A MODERN MANAGER IN AN OPEN SOCIETY: DEVELOPMENT OF ALGORITHMIC COMPETENCY OF A PUBLIC GOVERNANCE SPECIALIST

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ABSTRACT

The article analyzes approaches to reformation of public administration principles through the use of information and telecommunication methods. The transformation lies in the necessity of developing and acquiring competencies, fulfilment and implementation of algorithmic tasks in the process of managerial decision-making. It highlights legislative initiatives and concepts, which determine the state government's core effort in implementing electronic governance, e-document management and online interaction between public administration specialists and the society. The concept of *algorithm* is considered separately. The research has helped to explain the reasonableness of using algorithms as a relevant resource that ensures consistent managerial work on the part of a public administration professional, to achieve the best result. It highlights the relationship between the concepts of *public administration* and *algorithmic competency* as integral elements of modern managers' informational and digital awareness.

The article describes the concept of *algorithmic competency* as a connection between *algorithmic culture* and *algorithmic thinking*, and it reveals a relationship between summation of algorithmic instructions in management and building schematic flowcharts in programming. It describes the reasonability of using this relationship for professionals to prevent errors in managerial decision-making. Specialists' ability to organize their activities into algorithms and carry out algorithmic categorization (skills, thinking, culture) is an effective tool against errors, both in the process of managerial decision-making and afterwards, particularly when public management specialists are building and performing an algorithm of consecutive managerial activities.

INTRODUCTION.

Today, the process of development of Ukrainian society is characterized by a growing managers' concern about the algorithm development process. The public management practice is focused on renovation of public administration through the use of advanced technologies. Public administration as a form of management of governance processes, ensures much more effective managerial work. The progressing Internet-based decision-making technologies cannot rely on traditional methods only, because they do not enable a today's manager to analyze and predict results.

Modern public governments' striving to integrate ICT in their work is changing the style of cooperation between the government and citizens of Ukraine. Both scientific discourse and everyday governmental work often incorporate digital information technologies, electronic governance, digital management, digitization and smart technologies. All this poses a variety of situational tasks for public governance specialists, which require building and performance of an algorithm to help them make an effective managerial decision.

First of all, this requires improvement of a specialist's algorithmic competency, as the social sphere is getting regulatory support. The changing legislation is just one precursor to more advanced training of the public in the basics of cybernetics and drafting vectors for gaining algorithmic competencies (know-how and skills) in the world of state-of-the-art information and communication technologies.

In the context of reforms taking place in the state, education (training, specific job preparation and in-service education) in the basics and technologies of secure management of information for today's managers, development of algorithmic competency is gaining ground; this requires specific professional research in the sphere of public administration.

Review of recent papers on the subject. Determining unresolved aspects of the whole problem. Research of recent papers has demonstrated that the subject of public administration specialists' algorithmic competency is not fully studied. A scientific paper review has shown that they do not analyze the degree of algorithmic competency development and do not address the relationship between creation of an algorithm through obtaining professional competencies and use of algorithmic instructions in the process of managerial decision-making along with incorporation of ICTs. Matters related to incorporation of algorithms into public governance specialists' work have not been fully considered in scientific literature.

It has been found that at this point public governance specialists should remember that intellectualization of public governance has undergone a few regulatory changes, because they do reflect the focuses of informatization and digitization of public governmental agencies, and are now part of the state's general strategies and documents. In the context of this research, it is necessary to highlight: the Information Society Development Strategy of Ukraine, 2013 (it

regulates incorporation of advanced information and communication technology into all spheres of public life, governmental bodies' and local government agencies' work); the Sustainable Development Strategy "Ukraine – 2020" (2015) (it incorporates a program for popularization of Ukraine in the world and steps to promote Ukraine's interests in the global media space); The law of Ukraine dated 05/10/2017 No. 2155-VIII "On trust services." They agreed on the Provision on Electronic Interaction between National Electronic Media Resources and a list of priority national media resources, which have increased the effectiveness of electronic governance in the sphere of public service [2; 3; 4; 5].

In this situation, Ukraine is very interested in using the experience of nations, where electronic administration has proved very effective. This testifies to governments' ability to take advantage of information and communication technologies to boost competitiveness and quality of life, as they rely on the Networked Readiness Index (NRI), which has been in use since 2002. According to World Economic Forum publications, in 2014 through 2016, Finland, Singapore and Sweden topped the international NRI chart [6;7;8; 9, P. 124-130].

Notwithstanding the numerous studies of the basics of algorithm development in public governance in Ukraine, which uses ever-evolving and improving technologies, their use and incorporation by modern governmental institutes necessitates professional research of algorithmic competency.

The objective of the paper is studying the development of specialists' algorithmic competency in public governance as part of informational and digital competency as one of the tools used to prevent errors in managerial decision-making.

RESEARCH METHODS

Managerial experience has shown that many, especially young people, believe that the only reason why they should study computer science is the necessity of learning to operate PCs, but this is wrong. Most people are unaware that every person has to face countless tasks every day, simple and well-known and extremely difficult. Many tasks have specific rules (instructions, commands), which explain to a contractor how the problem should be solved [1;8].

Experience shows that specialists have studied these rules at school or developed them when solving various tasks. The more accurately these rules will be formulated, the sooner a specialist will learn them and the more effectively he/she will use them. We spend our lives making descriptions of a string of activities, which is even more typical of today's managers, to achieve the desired result, so the concept of algorithm is no new or extraordinary thing for us. However, there are spheres, including public governance and administration, within which the concept, properties, compilation and execution of algorithms turn out to be ineffective [11].

A public administration specialist should use hundreds of algorithms, some of which are managerial algorithms and those intended for solving situational tasks in the context of public administration.

The study of the algorithm concept begins in the school programme of computer science, is fundamental, that is, one that is not determined through other simpler concepts [12].

L. Fridman offers detailed characteristics of an educational algorithm. "We understand an educational algorithm as an instruction, using which any professional, who has an appropriate background for following the instruction, can properly solve any such task" [11, P. 69].

We have studied scientific sources to reveal the basic concept of *algorithm* relative to the study focus and its role in the development of a public administration specialist's competency [10]:

- an algorithm is formulation of rules of the four arithmetic operations with multi-digit numbers (the rules of choosing algorithms have been determined). And it is noted that not all instructions or string of operations can be termed an algorithm;

- an algorithm is a group of marks denoting a string of operations, which result in solving various practical (including managerial) tasks (rules of building and running algorithms). Therefore, an algorithm performer (particularly, a computer) can run only a limited set of operations.

- an algorithm is a clear and concise definition and instruction for a performer to execute a string of operations aimed at fulfilment of the objective and solution of the task (uses of algorithms have been defined). It has been found that the definition uses the concept of *performer*. The performer is any being (animate or inanimate) capable of executing an algorithm. This depends on the type of the objective. For example, digging a hole can be executed by a person or excavator, solving a mathematical problem – by a student or computer, a managerial/governance decision – by a manager or computer (preferably a manager), and more.

- an algorithm reveals signs and properties of all activities, including managerial, persons (properties of algorithms, which define the result of managerial activities, have been determined). Any algorithm has specific properties, but they do not always predetermine the result of managerial work.
Research of scientific sources has revealed the most common characteristics of an algorithm. These include [11; 12]:

1. Understandability (every command that is part of an algorithm must be understood). In order for a performer to fulfill the objective using a given algorithm, he/she should be able to perform all instructions and understand each command within the algorithm.

2. Unambiguity (an understandable algorithm should not include ambiguous instructions, so once an instruction is fulfilled, the performer should be able to foresee his or her next step. Therefore, precision is a property, which prevents

ambiguous interpretation of an algorithm, so the performer knows what to do next.

3. Discreteness (an algorithm sets a complete string of operations, which should be executed to resolve a task). In order to fulfill these operations, they are dissected into simpler ones. It is impossible to complete an operation without completing the previous one. Such divisibility of an algorithm into separate simple operations (commands), which are easier to perform, is called *discreteness.*

4. Mass nature (it is important that an algorithm should solve a broad spectrum of tasks, not just one, of a particular type, including managerial).

5. Performance (obviously, execution of any algorithm should have a positive result). When producing an algorithm, it is necessary to rule out any possibility of situations that could lead to circling.

6. Effectiveness (every part of an algorithm must be executed properly and within a specified period of time).

Analysis of the main characteristics of an algorithm has helped in determining its basic properties [10]. It has been discovered that:

- many programs require initial values. These values are incorporated in an algorithm with the help of arguments. An argument is a value, which needs to be determined for proper execution of an algorithm;

- there is no algorithm without a result. What kind of content an algorithm would have otherwise? Results are values, which appear after the execution of an algorithm;

- apart from arguments and results, many algorithms at the stage of building, require additional values. Use of these intermediate values is determined by the creator. Intermediary values are added during the algorithm development process.

These properties have helped reveal ways of introducing an algorithm to the performer. There are several methods of expressing algorithms, and the choice of one depends on the creator and performer [10]. These include: verbal description, tables, formulas, diagrams, pictures, etc. Some algorithms are expressed as flowcharts. Computer science uses this method by reason of its demonstrativeness, as it is expressed in a set of blocks - algorithmic languages (pseudo-codes). These languages have a robust syntax and have a close resemblance to a computer language (programming language). The method is maximally computerized, as it uses programming languages. Mostly, a computer is the performer of these man-made algorithms; therefore, they should be expressed in a programming language, which is understandable for a computer.

There is an example of how these properties can help solve a situational task (Euclid's algorithm [12]), which consists in:

1. Computing the greatest common divisor of two natural numbers – *m* and *n* (Euclid's algorithm). The task solution algorithm will be based on the fact that if m>n, the greatest common divisor of the two integers (m and n) is the same as of the numbers m-n, n.

2. The general algorithm is:

1. Accept either of the two numbers as the answer if they are the same; if they are not, continue the performance of the algorithm;

2. Find the greater one;

3. Replace the greater number with the difference between the greater and the smaller number;

4. Run the algorithm again.

Here is an example of using a general algorithm for solving tasks in the public sphere.

Step 1. If there are several candidate solutions, one can choose answers at his or her own discretion;

Step 2. Checking the statement and analyzing the target result;

Step 3. Choosing the most optimal candidate solution;

Step 4. Outlining a succession of managerial activities;

Step 5. Continuing to perform the algorithm. Choosing the most acceptable managerial activities.

Step 6. Explaining and specifying the result.

Step 7. Running the algorithm again if no satisfying result is achieved.

The research has demonstrated that the most important managerial decision-making factors for a specialist are: algorithmic competencies (developing data structuring skills in a public governance specialist); algorithmic thinking (following an algorithm during work); algorithmic culture (building and performing algorithms).

Based on the research, it is these components that determine a public governance specialist's competency. They are the tools that prevent professionals from making errors, particularly public governance specialists. An algorithm (after an Uzbek mathematician – al Khorezmi) is a set of instructions (algorithmic knowledge and skills), which describe the succession of a performer's activities

(algorithmic thinking), aimed at achieving the result per number of operations (algorithmic culture) [10]. A specialist's algorithmic thinking enables him/her to clearly see all steps than need to be followed, obstacles, and effective ways around them).

It has been proved that algorithmic competency (algorithmic competencies, thinking and culture) is part of professional competency along with other competencies. This underlies the singular concept of a the competency of a specialist, who is capable of making individual decisions and accepting responsibility for them, professionally performing managerial work in every sphere, carrying out specific tasks or work.

The concepts of competency and competency development originate in the western educational vocabulary and over the past few years have become study objects for international organizations, which come up with competency building recommendations. It appears that public is dissatisfied with the results. Research has shown that today's labor market demands people with more than just cognitive qualities and skills, which actually define a person's competency. A well-educated person can be absolutely incompetent in modern spheres, such as math – the language of science, and ICT – the infrastructure of science. Every public administration specialist should be aware that ICT-competency comprises a system of competencies, which determine the algorithm performance order, a string of algorithmic managerial operations: technological competency (ability to operate advanced ICT tools and packages (hardware and software) in solving current managerial tasks in the modern information society); investigator competency (ability to operate ICT tools, use application and research methods in various spheres, including public governance and administration); modeling competence (awareness of the basics of the modeling theory, computer modeling, accepting a computer as a universal managerial decision-making tool); methodological competency (unlimited potential of and possible limitations on the use of ICT is solving today's and future social and individual problems). It should be noted that the aforementioned list of parts of ICT competencies is in a way rating-based (a higher position of a competency on the list means a higher ranking). All these competencies appear to integrate into algorithmic competency. Algorithmic competency has the following nature: An important part of competency-based education is obtaining algorithmic competencies. It is more of an acquisition rather than mastery, studying or learning. The only way to obtain competency is through personal intense and productive effort (it should not be confined to learning), creative work, and personal experience via social experience, its critical perception, or, in other words, through unique individual acquisition experience.

Reflected in the concept of acquisition are modern pedagogics and psychology, which, in both word and action, recognize every specialist's individuality, uniqueness of every person's experience, which deem productive just the development of cooperation. This development determines every public administration professional's creative being.
Scientific and methodological literature regards the ability to build algorithms as a basis for algorithmic thinking. Kopayev V. defines algorithmic thinking as a "system of thinking methods and activities, tricks, methods and respective

cognition strategies intended for solving both theoretical and practical tasks, and which produce algorithms as specific products of human work" [12, P.1]. Development of algorithmic thinking is closely related to the formation of the general problem-solving ability. In order to define a problem-solving method for a category of tasks in the form of an algorithm, first, the general method and, second, a way of describing this method as a set of meaningful and unambiguous consecutive operations should be found. Therefore, algorithmic culture is the foundation of algorithmic competency. Most scientists describe algorithmic culture as a group of personality traits and a certain level of algorithmic thinking, which ensure:

1. Understanding of algorithms' role in different spheres;

2. Ability to work according to a set algorithm (expanded or short);

3. Ability to make choices and apply algorithms in work;

4 Ability to build algorithms;

5 Ability to describe a problem-solving method in the form of an algorithmic instruction.

The didactic basis for development of algorithmic competencies in students has been presented by A. Kapinosov and V. Korolsky [13]. In organizing preventive work, algorithmic instructions act as an effective error prevention tool for specialists. We emphasize the close connection between the concepts of *information and digital competency, algorithmic competency, algorithmic thinking* and *managerial error prevention.* In their work [13], the authors describe levels of algorithmic competencies, as they believe that beginner, intermediate and upper intermediate specialists should be able to apply algorithms, and advanced specialists should be able to build them.

The most important role in managerial and administration work belongs to algorithmic instructions as the main error prevention factor. We share the scientists' opinions, although we believe that it is necessary to teach specialists to build and apply algorithms at all levels of public administration, and programming provides a basis for that. It is programming that implies a strict succession of operations (commands), and it is aimed at reaching the goal and solving a variety of managerial and governance tasks.

An analytical review of scientific literature has revealed three types of algorithms used in creating computer programs: linear, branching and recursive algorithms. We believe that learning the basics of programming creates a basis for building specialized algorithms. However, we admit the use of both graphic (flowcharts) and verbal (algorithmic instructions) methods. While relying on secondary school knowledge (math and computer science), a specialist should learn all basic commands and successfully apply them in public administration. Examples of linear commands include finding and compiling similar complex tasks, their generalization, using several candidate solutions, analyzing results and, if necessary, drawing charts, and making a managerial decision [12; 13].

A branching command is used when additional tasks are set (statement checking), generalized (statement analysis), and solved (estimating the result based on the statement), i. e. in tasks where it is absolutely necessary to check a situation in the process of solution. A repeat command can be used in tasks, such as: *analyze the development of education in the region and outline measures of improvement*. A repeat command may be: *how to find additional information* (or results of the development of education over the past five years).

Evidence shows that public administration specialists, in order to complete managerial and administration tasks, should be trained to create simple programs when obtaining bachelor and master degrees. It is advisable to show one what a flowchart looks like and figure out how to present managerial/administration tasks in the flowchart fashion. It appears that public management/administration specialists prefer to present algorithmic instructions in the form of a flowchart and vice versa.

An important part of training public administration is teaching students to make supportive notes. Flowcharts are the most demonstrative "human" kind of algorithm-writing language. It can describe a variety of physical, chemical and technological processes, including managerial ones. The ability to present one's ideas in the flowchart form greatly disciplines public administration specialists' algorithmic thinking and is an increasingly important practical quality, regardless of the type of profession. Specialists trained to build flowcharts can build textual algorithms much faster and make more effective managerial decisions. The practical importance of using flowcharts or algorithmic instructions, according to P.Ya. Galperin's theory of gradual development of mental effort, consists in the fact that the process of development goes easier and does not require cramming; instead, new material is memorized involuntarily during algorithm performance.

At the beginning of learning flowcharts, a specialist should learn how to describe a modern manager's life and managerial work in the form of a flowchart. A task may be set in the following way: 1. The size of employees' salaries depends on fulfilment of production plans, and the manager should provide for differentiation. 2. If a worker has completed work, he/she will be paid the whole sum. 3. If the production plan has not been fulfilled, he/she will be paid the minimal sum. 4. The manager must analyze and check the fulfilment of the production plan, specify errors, provide assistance, discuss resources, which a worker should use. 5. If there are no problems, the staff moves over to the next task. 6. An employee should fulfill the production plan.

Once specialists have learnt to translate algorithms into the flowchart form, they should be trained to build flowcharts of public governance tasks. It is recommended to start with simple ones for specialists to understand the way of thinking and memorize the order of operations. Flowcharts' demonstrativeness helps avoid errors that are typical of modern managers. To avoid these errors, specialists should learn to set tasks and build flowcharts on their own, depending on matters' actuality.

CONCLUSION

The review of modern algorithm development principles that should arrange a public governance specialist's operations, given the specifics of intellectualization of managerial processes, confirms the existence of a variety of approaches depending on the designation, and understanding of algorithms' nature, which can be categorized as: specialists' ability to algorithmically arrange their managerial activities, think in algorithmic terms, use algorithms to prevent errors during the decision-making process and later on, particularly when public administration specialists are building an algorithm of managerial activities.

An analytical review of the regulatory base and advanced approaches to arranging a public administration professional's activities with the help of algorithms also suggests a necessity and relevance of developing a respective algorithm-building technology; these approaches should be a convenient tool for analysis and development of effective managerial decisions and enable a modern manager to correct managerial operations.

In Ukraine, intellectualization of management and administration is facing problems. For this reason, a public governance specialist should be able to build and read algorithms, as well as perform managerial work in accordance with a completed algorithm. Methods of developing public governance specialists' algorithmic competencies require further research as a more advanced stage of digital transformation of public governance processes.

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