

## Assessment of functional literacy of students in computer science based on the criteria-based approach

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### Abstract

Everyone uses a traditional five-point grading system to assess students' activities, however, it is not always possible to objectively evaluate students' work using this method. Therefore, the authors use the criteria-based student assessment system in our lessons. The purpose of this article was to compile a model of a system for assessing students' functional literacy based on a criteria-based approach. An experiment was conducted on 32 people and data was collected using observation and interviews. As a result of the study, it was revealed that the assessment system makes it possible to determine how successfully one or another educational material is mastered, or a certain practical skill is formed. Based on the conducted practical experiment, the effectiveness of the content-structural model of the system for assessing the functional literacy of students based on the criteria-based approach in computer science has been proved.

**Keywords:** Criteria-based assessment; computer literacy; integrated information; self-assessment procedures.

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## 1. Introduction

The essence of criteria-based assessment in the educational process is to establish feedback between a teacher and a student, which allows identifying the features of the learning process, obtaining by the assessment subjects objective information about a degree of learning material mastering. Criteria-based assessment technology extends not only to the formation of key competencies of students but also to the level of formation of creative, critical thinking, attention, educational motivation, and the degree of formation of students' worldview (Vygotsky, 2012; Amonashvili, 2012).

In computer science lessons, criteria-based assessment is in demand and at the same time effectively implemented. In computer classes in practical classes, students work mostly independently, both with digital data information and with the presentation of a variety of information. In this case, it is required not only to evaluate the result but also the skills to work with hardware and software to implement this or that idea, to solve the task set by a teacher – to combine the criteria of the educational result itself and the criteria for evaluating the process of achieving it. It is worth noting that with the independent fulfillment of the assignment in the classroom by a large number of students, especially in the main school, it is quite difficult for a teacher to track and evaluate the process of individual work performance (for example, the rational use of techniques).

Criteria-based assessment is, according to the definition of A.A. Krasnoborova, a process-effective meta technology that provides a system of interconnected controlling-assessing actions of all participants in the educational process to achieve the goals and objectives of training (Krasnoborova, 2009). It differs from the normative-oriented one, in which the work or students are assessed as to how well the work is done by other students. The purpose of criteria-based assessment is to determine and increase the level of students' success by utilizing criteria allowing to connect the assessment system with the settings indicated as a separate training course, as well as the possibility of building students' competencies at the appropriate educational level. In accordance with this goal, the assessment system itself is aimed at obtaining information that allows students to gain confidence in the successful inclusion in the system of continuing education; parents to observe directly the development process of their child; teachers to judge the effectiveness of a program, the progress, and achievements of students.

There are rules of the organisation of the criteria-based assessment system according to Romanov (2010) the evaluated work and actions for its assessment will allow both a teacher and a student to determine successes and failures, to plan steps to increase the level of success in the future; understanding and application of knowledge, skills and abilities is easily verified; students are assessed in accordance with general assessment criteria, achievements are noted for each of the criteria; students know the criteria for assessing an assignment before they begin to do it (as necessary, they are involved in the discussion or creating rubrics); students are given the opportunity to analyse their own level of learning and determine what needs special attention and improvement; the joint activities of educators are encouraged in order to develop common approaches to the assessment process; the results of assessing the work performed are available only to a student himself, if necessary, and his parents, teachers and representatives of the administration; assessment takes place as objectively as possible, regardless of personal sympathies, which is achieved by a clear description of the procedure and the creation of detailed categories.

The authors examined the experience of using criteria-based assessment in computer science lessons by teacher Suleimenova. The researcher believes that using this system is easier to evaluate the student when working with projects. Considering the grading system of A.S. Suleimenova, the authors undoubtedly noted positive results. The only thing that is not very convenient here is the large number of grades when adding up. There is no independence of students in formulating criteria, and also, she did not find methods of mutual assessment. After

analyzing the development of various authors, the authors concluded that: the criteria-based assessment tools in the computer science course contain descriptors for evaluating both the educational result and the process of performing practical tasks; at various levels of education, schoolchildren can be involved in the formulation of criteria, with varying degrees of independence.

So, when teaching schoolchildren computer science, the authors used assessment criteria, both developed by methodologists (Demidovich, 2011), and developed by them and the students themselves in the classroom (Sagimbaeva, Zaslavskaya, Avdarsol, 2019). Applying criteria-based assessment in the lessons, the authors believe that descriptors need to be developed together with colleagues, and in high school with the students themselves, which allows students to form a positive attitude towards assessment and increase their responsibility for achieving results. The assessment can be either rating or classic. Criteria-based assessment can only make up part of the formative assessment per lesson, or, based on the number of points scored, a total assessment can be set, depending on the form of work.

### **1.1. Conceptual background**

In determining functional online literacy, the study by Dolenc, Aberšek, and Aberšek (2015) shows that there are differences in reading comprehension when reading offline and online when using electronic school material in their educational process. The study involved 78 students in the 8th grade of primary school, studying the course "Technology and Science". The authors used individual and adaptive intelligent learning systems (ITS) and, using the assessment of the results, showed that for this form of ITS there is still enough room for optimization, which is a constant method of improvement and updating in such systems (Dolenc, Aberšek, Aberšek, 2015) .

The article by Quarstein & Peterson, (2001) examines a model developed by the authors to evaluate non-traditional teaching methods, such as group learning. This model was applied to group training courses, which included innovative enhancements such as group exams and group-based role-playing games. The model required a balanced presentation among the set of learning criteria, grouped into six sets of target criteria, all of which are taken from the literature on group learning. The authors developed a test tool based on this model and presented it to 85 students at the end of three courses in business strategy (Quarstein & Peterson, 2001). The purpose of this study is to compile a model of a system for assessing students' functional literacy based on a criteria-based approach to computer science. Based on a practical experiment and the proposed criteria approach, show the effectiveness of the model of the system of evaluating the functional literacy of students in computer science.

Functional literacy is the result of education that provides the skills and knowledge necessary for personal development, obtaining new knowledge and cultural achievements, mastering new technology, successfully fulfilling professional duties, organizing family life, raising children, and solving various life problems. Bezrukova (2000) in the encyclopedic dictionary of a teacher, defines functional literacy (lat. direction) as the degree of a person's preparedness to perform the functions assigned to him or voluntarily taken over. The pedagogical dictionary of L.P. Rusinova indicates that functional literacy is the level of education, characterized by the degree of mastery of the cognitive means of the main types of life; this level is characterized by the ability to solve standard life tasks in various spheres of life-based on mainly applied knowledge (Rusinova, 2010) .

The opposite – is functional illiteracy, which does not allow a person to understand technical instructions, programs of political parties, and complex tests. Oleshkov (2006) defines functional literacy as the level of education, which is characterized by the ability to solve standard life tasks in various spheres of life based on mainly applied knowledge. In the era of digital technologies, functional literacy develops in parallel with computer literacy; therefore, for the successful development of functional literacy among schoolchildren and achievement of key and subject competencies in computer science lessons, the following conditions must be observed: training in computer science lessons should be active; the educational process is focused on the development

of independence and responsibility of a student for the results of his activities based on ICT; the opportunity is given to gain experience in achieving a goal; certification rules are clear and understandable to all participants in the educational process; productive forms of group work are used; the transition from front-line forms of class collective education to the implementation of an individual educational path for each student, including using interactive innovative, design and research technologies, digital infrastructure.

The expected results of students in computer science give the opportunity to objectively assess their educational achievements and determine their development paths, taking into account the abilities of each student, also contribute to stimulating students' abilities and expect improvement in the quality of the educational process. By studying in one class, one program, and a textbook, students can learn the material at different levels. The determining factor is the level of compulsory training. Its achievement indicates that a student has fulfilled the minimum requirements for mastering content. Based on it, higher levels of mastery of material are formed. Recently, this type of differentiation has come to be called *level differentiation* (in addition to level differentiation, there is also profile differentiation) (Sagimbaeva et al., 2020).

*Level differentiation* (according to E.S. Polat), should be understood as such an organization of an educational process in which each student has the opportunity to master the educational material at different levels, but not lower than the basic, depending on the desire, abilities, and individual characteristics of a person. Moreover, the evaluation criteria are students' efforts to master the material and its creative application (Polat, Bukharkina, Moiseeva, Petrov, 2001). The implementation of intra-class level differentiation involves taking into account such features of students that affect their educational activities and on which the learning outcomes depend. These may be various physical and mental qualities and states of personality: features of all cognitive processes and memory, properties of a nervous system, traits of character and will, motivation, ability, giftedness, etc (Veriaev, Nechunaeva, Tatarnikova, 2013).

Criteria-based assessment is built on the criteria-based approach — it determines the level of a student's approach to the expected learning outcomes. The objectivity of assessment in criteria-based assessment is confirmed by descriptors, students participate in their education, moderation, discussion, and comparison of assessments. The new grading system allows students to be active not only in the learning process but also in evaluating learning outcomes. The system of criteria-based assessment allows a teacher to note what more can be learned taking into account the directions of growth and paying attention to the achievements of students. In world practice, the meaning of the concept of "quality of education" is understood differently, and is evaluated according to specific criteria determined based on the taxonomy of goals.

The quality of training is the correlation of goals and learning outcomes, while the goal is only operational and accumulated in the nearest student development zone. That is, training is recognized as high-quality if results meet specified diagnostic goals and cover a potential area of development of a student. The purpose of the operational (diagnostic) setting of learning goals is characterized by the fact that they are formed using the learning outcomes reflected in the students' activities, which can be accurately measured and recognized. The most popular goal system with such qualities is Bloom's Taxonomy of Educational Objectives.

The six main stages of Bloom's Taxonomy can be seen as a hierarchy of skill and ability, the level of tasks recommended by students. Here is the word "task" used in a broad sense – this is a question that can be a question of a teacher, training, tasks, project, etc. In addition, since training at the levels of "knowledge" and "comprehension" leads to superficial learning, for teachers to develop functional literacy to offer tasks that require a high level of thinking – "application", "analysis", "synthesis" and "evaluation".

Thus, the characterization of taxonomy levels can become an algorithm for the development of developing tasks. It can be said that the operational setting of learning goals is also a prerequisite for

organizing and conducting developing learning, developing functional literacy of students, as well as putting into practice a criteria-based system for assessing student knowledge. Since the training paradigm was chosen as a way of personal activity, the content of each level of the three-dimensional methodological system is formed in the form of the necessary multi-level tasks that develop students' independent cognitive activity. With the help of this learning technology, three levels of development of the methodological system can be defined. They are as follows:

1st level – reproductive. There should be convenient definitions, concepts, rules, etc., as well as questions, tasks for repeating and working out new knowledge in the previous lesson, that should be effective for a new topic, and situational tasks related to life.

2nd level – algorithmic. The use of previously mastered, reproductive, algorithmic effects. Students carry it out independently, using information about previously mastered indicative basics of this activity.

3rd level – creative. Application of previously acquired knowledge and skills for solving atypical tasks. This is a productive activity in which students or subjective new information (only new to themselves) is heuristic activity, or when they act “without rules” they create objectively new, but different rules of action in the area in which they know, i.e. conduct research work (Sagimbaeva, Avdarsol, Zaslavshkaya, Arynova, Baimakhanova, 2020).

Assessment criteria are developed by taking into account the requirements of a standard for academic discipline, and methodological recommendations. The criteria are not absolute, the assessment of similar activities varies with the age of students. The following are examples of student assessment criteria. A typical curriculum on the subject “Computer Science” for 5-9th grades of the level of basic secondary education with updated content. Below are assignments for the following 4 sections of topics for 7th grade:

1. The section “Computer Systems” includes the following subsections: computer devices; software; computer networks.
2. The section “Information Processes” includes the following subsections: presentation and measurement of information; creation and transformation of information objects.
3. The section “Computer Thinking” includes the following subsections: modeling; algorithms; programming.
4. The section “Health and Safety” includes the following subsections: ergonomics; information and online security (Typical curriculum on the subject “Informatics” for 5-9th grades of the level of basic secondary education with updated content. Minister of Education and Science of the Republic of Kazakhstan dated October 17, 2018, No. 576.)

## **1.2. Purpose of study**

Everyone uses a traditional five-point grading system to assess students' activities, however, it is not always possible to objectively evaluate students' work using this method. Therefore, the authors use the criteria-based student assessment system in our lessons. The purpose of this article is to compile a model of a system for assessing students' functional literacy based on a criteria-based approach.

## **2. Materials and Methods**

### **2.1. Data Collection Instrument**

Teaching computer science involves mainly the development of user skills, in particular computer skills and digital technologies. Therefore, when studying some topics, practical work on the computer is conducted. The research used an experiment and collected data using interviews and observation.

When developing and testing experimental integrated educational programs in subjects, the approach used by Nazarbayev Intellectual Schools in conjunction with the Examination Council of the University of Cambridge partially began to be used. In the experimental and control groups, it was carried out according to our functional tasks and tests.

## **2.2. Participants**

The experimental group consisted of N=15 people, and the control group consisted of M=20 people. During the experiment, students participated in the discussion of assessment criteria, in the lessons and at home, in accordance with the above planning, they completed the developed tasks on functional literacy and went through the procedures of formative and summarising criterial assessment. For this work, the experimental groups and the number of students in them were determined. The effectiveness of the proposed methodological system during the training period was evaluated using a comprehensive test.

## **2.3. Analysis**

For an accurate analysis of the results, the following increase (gradation) of success and completeness was used: 10-8 correct points – 5 (90-100 points), 7-5 correct points – 4 (75-89 points), 4-2 correct points – 3 (50- 74 points), 0-2 correct points – 2 (0-49 points). The maximum number of tasks is 10. As a control work, functional tasks in informatics were created. Participants (N = 32) were interviewed before and after the teacher education process, and data were analyzed using qualitative and quantitative methods.

## **2.4. Procedure**

The authors consider the creation of vital situational tasks in the formation of functional informatics literacy. Assessment criteria are developed by taking into account the standard requirements of the discipline, and guidelines. The sizes are not absolute, the assessment of such events varies depending on the age of the students. The following are examples of criteria for assessing students' knowledge, skills, and abilities. To implement the competency-based approach in teaching computer science, it is necessary:

- to answer the question- “Where do you encounter objects in life phenomena?”, “Where do you use this knowledge and business in life?” to regularly ask questions about the species;
- to systematically competently introduce tasks to the audience;
- to use summary reports in the synthesis of the studied material;
- to consider work with educational projects.

The authors consider the creation of vital situational tasks in the formation of functional literacy in computer science: For example:

Level 1: Section “Computer Systems”

Theme: “Measurement of information and computer memory” (7th grade)

The task: The student is in 7<sup>th</sup> grade. He is a hard worker, attends various courses, loves to read e-books, is an Internet user, maintains his blog, and communicates with friends from different cities and countries through social networks. He loves literature, writes essays, and publishes articles in school newspapers. He read a new book. The book consists of 100 pages. Each page consists of 60 lines, and each line contains 80 characters. Help determine the volume of the book. Decision; Explanation.

Level 2- The tasks: Colour raster graphics with 65.536 colors, 100x100 pixels (pixels) in color. How much BMP format does this image occupy in PC video memory?

1. Determine how much video memory you get.

2. Arrange the units of information in ascending order on the graph (Figure 1). Assessment criteria of level tasks are in Table 2.

**Figure 1**

*Curriculum for the arrangement of information units*



Level 3: The task: The race will be attended by 119 athletes. A special device records its number and records the passage of the intermediate finisher using the smallest possible number of 70 bits for each participant. What is the size of the device message after 70 cycles? Determine the amount of information (Table 1).

**Table 1**

*Scheme for solving the problem of determining the amount of information*

Information units	Solution	Explanation
Bit		
Byte		
kilobyte		
Megabyte		
Gigabyte		
Terabyte		
Petabyte		
Exabyte		
Zettabyte		
Yottabyte		

**Table 2**

*Assessment criteria by levels. The maximum score for one task is 9 points.*

No. Assessment criteria	Descriptor	Difficulty level		
		1 level	2 level	3 level
1	Defines the concept and types of information	03		
2	Describes information properties		03	
3	Justifies the need to determine the properties of information.			03
	Converts numeric values from one unit of measure to another;			
	Checks the size of files in various formats in which information is stored.			
		<i>Total</i>		<i>score – 9</i>

In other words, the effectiveness of training with the help of level tasks is based on the completion of a material, as a student repeats and completes the lesson, performs tasks and additional tasks described in the textbook related to the topic, a student does not only checks himself, but also analyses and corrects his mistakes, and also checks the quality of knowledge, clearly sees the results of his knowledge, perform tasks that increase their mental abilities. There are various approaches to the assessment and development of functional literacy of students, one of the most effective of which is the implementation, solution, and evaluation of situational tasks

(Veriaev, Nechunaeva, Tatarnikova, 2013).

The studies introduced self-assessment procedures in a lesson extended for seven weeks in a European high school. Researchers used three assessment modes based on paper and pencil, computer networks, and mobile devices, respectively. The purpose of the study is to study the influence of each method of criteria-based assessment on the motivation and achievement of students in performing functional tasks. An analysis of pre-and post-motivational tests revealed a more positive motivational orientation of students on computers and mobile devices as a means of assessment. In addition, the student assessment carried out after the phase of the experimental procedure showed a significant increase in the performance of students with low academic performance who participated in mobile and computer assessments. The positive impact of computers and mobile devices on student learning motivation suggests that they can be used as a promising alternative to paper and pencil evaluation procedures (Nikou, & Economides, 2016; Badia & Campos, 2018; Jaakma & Kiviluoma, 2019; Keizer, 2020; Kilpatrick & Wolbers, 2020; Sangiorgio, Uva & Aiello, 2020).

The task of situational tasks is to describe situations that need to be solved by answering questions of a problem nature and (or) performing tasks that show the effectiveness of knowledge. For situational tasks, names are usually selected that indicates the context of the situation or problem-oriented solution. Situational problems for students can perform a number of functions: for example, updating the development of individual functional skills related to the acquisition of social roles (family member, city dweller, consumer, etc.); formation of basic competencies (information, communication). In many cases, work with various texts (reference, popular, scientific, artistic) is described, and their discussion and analysis will lead to the development of reading literacy. It is recommended to use a set of related case reports of interest. The content of situational reports usually includes typical, modern images.

For example Situational task No. 1.

Topic: Virtual reality or social networks: pros and cons

*Description of the situation:*

An educational institution wired the Internet. During the class hour in the 10th grade, one of the students suggested using the capabilities of social networks. The class was divided into groups. One group of students had no idea what it was. The second group supported the idea. The third group rejected the idea but did not provide convincing arguments. A class teacher suggested discussing the idea of connecting students to a social network in more detail. To this end, he introduced the students to the SWOT analysis methodology (Strengths, Weaknesses, Opportunities, Threats), which allows them to identify the strengths and weaknesses of the problem, and proposed a brainstorming session, the practical result of which would be to fill out a table of the following form (Table 3).

**Table 3**  
*Social networking capabilities*

"Pros" arguments +	"Cons" arguments –
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

After the work was completed, a group of specialists turned to a group of students. He recommended making out the messages according to the scheme below (Table 4).



**Table 4**

*The design scheme of the completed task*

Social networking capabilities	How a capability can be implemented	Which social network should be addressed first
--------------------------------	-------------------------------------	--

*Appeal to students.* The presented situation is quite typical. This problem may occur in your team too.

*Tasks and questions for analysis of the situation*

Imagine your solution to the problem of using social networks. To this end:

1. after conducting a brainstorming session, draw up an option for filling out the table No. 1 in the assignment, entitling it “Social networks: SWOT analysis”;
2. after analyzing the practice of social networks known to you, propose the option of filling out the table No. 2 in the assignment entitling it “Social networks in the life of modern youth”.

Situational tasks No. 2. Topic: “Information, information processes”.

**Task No. 1**

Currently, there is no single definition of information as a scientific term. From the point of view of various fields of knowledge, this concept is described by its specific set of features. According to the concept of C. Shannon, information is the removed uncertainty, i.e. information that must remove, to one degree or another, the existing uncertainty of the consumer before they are received, to expand his understanding of the object with useful information.

From the point of view of Gregory Beton, the elementary unit of information is “an indifferent difference” or an effective difference for some larger perceiving system. “Any perception of information with necessity is receiving information about the difference.” From the point of view of informatics, information has several fundamental properties: novelty, relevance, reliability, objectivity, completeness, value, etc. The analysis of information is primarily done by the science of logic. The concept of information was considered even by ancient philosophers.

Question: What is information?

Answer: Information is data, explanations, and familiarisation with the outside world.

**Task No. 2**

Question: Why is a computer a universal tool for working with information?

Answer: The word “universal” emphasizes that a computer can be used for many purposes: to process, store and transmit the most diverse information, used in a variety of human activities. But no matter what a person does using a computer, it is always working with information.

**Task No. 3**

Find errors in the following sentences and identify their nature:

1. Information is stored, transmitted, and processed in any form.
2. The “Relevance” information property is always important and essential.

Computer science is a field of human activity associated with processes of information transformation using computers and their interaction with the application environment.

Answers:

1. Information is stored, transmitted, and processed in symbolic (symbol) form.

2. The “Relevance” information property is important and essential for the presenttime.
3. Computer science is a science related to the processes of information transformation using computers and their interaction with the environment.

**Task No. 4.** Give your examples of professions in which the main activity is working with information.

**Task No. 5.** Give examples of situations in which you are a source of information, a receiver of information. What role do you often have to playtoday?

Situational tasks No. 2. Topic: Social networks. Read the text and complete the task.

Gulim plays one of the multiplayer online games on “VKontakte”. When he first started the game, everything was very simple and interesting. However, over time, Gulim realized that if he wants to continue to remain in the game, he should attract as many of his friends as possible, since his success directly depends on it. At first, he managed to persuade several close friends to join the game, and this had a positive effect, but not for a long time. Then Gulim began to send invitations to join the game to all his friends. Some of his friends accepted the offer, but some refused. This was not enough for Gulim, and he began to send invitations repeatedly over and over again until they began to remove him fromthe list of contacts. Then Gulim began to look for new “friends” from among the same players like himself. As a result, complete “strangers” became his “friends”, and the friends whom he knew removed him from the contact lists, and many of them ceased to communicate with him inreal life.

Formulate 3-5 sentences about the dangers of online games. Functional literacy assessment can be done verbally and in writing. In this case, students will be prepared in advance for the text of the assignment, and the assignment will be completed in the classroom. Assessment of written assignments can be performed by a subject teacher or school administrators – educational instructors. The assessment of the written assignments of tasks uses the situational matrix of the assessment of tasks (Table 5, Table 6).

**Table 5**

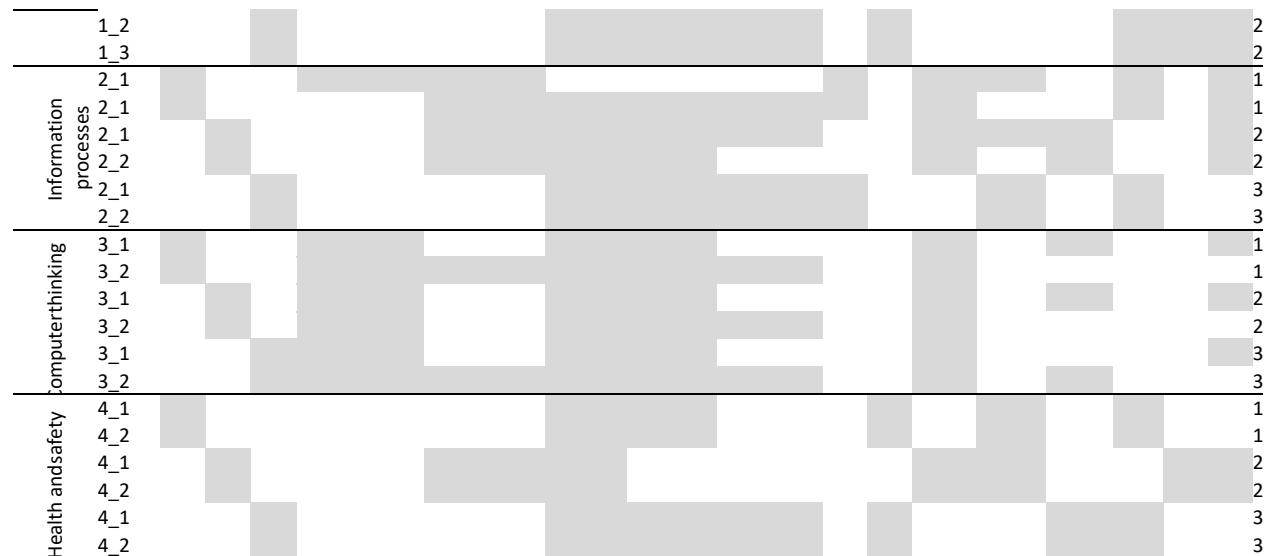
*Matrix to assess situational tasks*

No	Name of an assignment	Where the task was performed (inthe classroom, at home) and (independently, in the group)	Assessment of criteria											
			Understanding the text				Suggest solutions (tasks)				Substantiate solution of the problem			
			0	1	2	3	0	1	2	3	0	1	2	3

**Table 6**

*Content-structural model of a system for assessing students' functional literacy based on a criteria-based approach*

Section	Topic	Difficulty level	Criteria-based assessment system						Recommended types of activity in class						Score				
			Level of thinking skills			Skills of high level			Work Group work	Individual work	Formative assessment	Teacher' s explanation	Demonstration	Experiment		Self-esteem			
1st level	2nd level	Knowledge and comprehension	Application	Analysis	Synthesis	Assessment													
Computer system	1_1	1st level																1	
	1_2	2nd level																	1
	1_1	1st level																	1
	1_2	2nd level																	1
	1_1	1st level																	2



The application of the criteria-based approach in the educational system makes it possible to identify and improve the system for assessing student performance with the objective goals of an individual subject, as well as using certain parameters (criteria) that allow students to compete in high school.

### 3. Results

The monitoring results are shown in Tables 7, 8, and Figure 2.

**Table 7**  
*Results of monitoring the EG and CG*

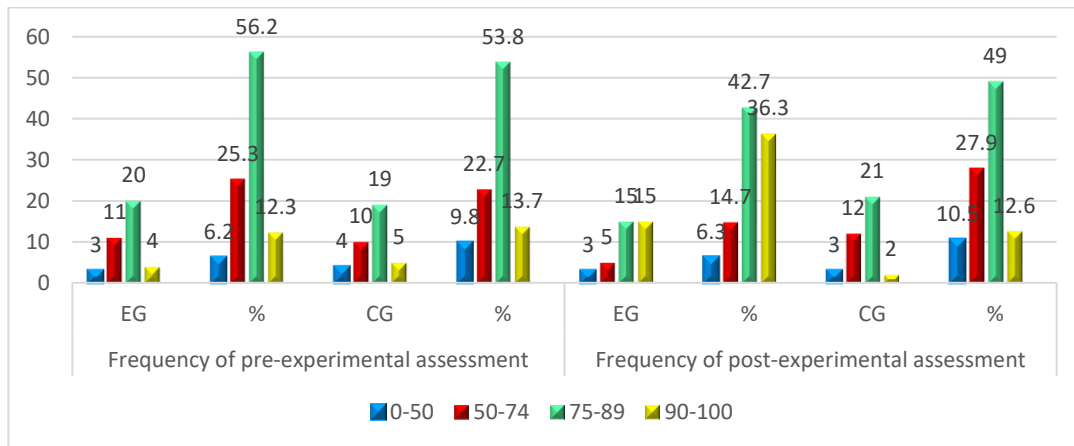
	Initial data before the experiment			Initial data after the experiment			
	1		EG	2			
EG	CG	CG		EG	CG	CG	CG
5	4	4	3	5	4	2	4
6	4	7	4	10	5	6	4
3	3	6	4	7	4	6	4
1	2	7	4	1	2	5	4
4	3	4	3	7	4	3	3
9	5	1	2	9	5	1	2
2	3	7	4	4	3	6	4
7	4	6	4	7	4	5	4
5	4	4	3	10	5	3	3
6	4	6	4	9	5	5	4
4	3	1	2	4	3	1	2
6	4	7	4	6	4	6	4
5	4	3	3	9	5	2	3
3	3	5	4	1	2	6	4
5	4	3	3	6	4	2	3
6	4	6	4	7	4	5	4
2	3	6	4	4	3	5	4
6	4	7	4	7	4	7	4
6	4	5	4	7	4	6	4
5	4	3	3	9	5	2	3
7	4	6	4	7	4	5	4
5	4	3	3	8	5	5	4
1	2	2	3	4	3	2	3
6	4	6	4	10	5	5	4
6	4	9	5	7	4	9	5
9	5	5	4	10	5	6	4
7	4	6	4	7	4	5	4
8	5	10	5	9	5	10	5
6	4	8	5	7	4	9	5
5	4	1	2	6	4	1	2
4	3	5	4	4	3	4	3

6	4	6	4	7	4	3	3
7	4	8	5	7	4	9	5
2	3	7	4	6	4	4	3
10	5	9	5	10	5	7	4
8	5	8	5	9	5	7	4
6	4	2	3	10	5	1	2
3	3	7	4	6	4	4	3

**Table 8**  
*Initial data grouped by frequency scale based on an assessment*

Assessment	Frequency of pre-experimental assessment		Frequency of post-experimental assessment	
	EG	%	CG	%
0-50	3	6.2	4	9.8
50-74	11	25.3	10	22.7
75-89	20	45.5	19	42.7
90-100	4	9.1	5	11.3

**Figure 2**  
*Results before and after the experiment of EG and CG control*



The main question of the training experiment: “Is there any progress in acquiring knowledge, and practical skills in the group that uses the methodology developed by us?” To find the answer, it is necessary to find a series of results. One such measure is a description of the central trend of the data, as well as the variability of the data around the distribution center. An important statistical characteristic of the distribution center is the arithmetic mean.

Other characteristics of the central tendency — the most commonly used option — are modality and median, which divides the sum into two equal parts. Often dispersion is seen as a characteristic of the dispersion around the center. Another important issue that needs to be considered when analyzing data is whether the distribution is subject to the normal distribution law. This problem is solved by comparing the median, mode, and median. The distribution characteristics of the baseline data from a table grouped by price frequency are obtained (Table 9).

**Table 9**  
*Characteristics of the distribution of the assessment in the experimental and control groups*

Parameters	CG		EG	
	Before the experiment	After the experiment	Before the experiment	After the experiment
	38	38	38	38
Minimum	1	1	1	1
Maximum	10	10	10	10
Interval	9	9	9	9
Addition	205	181	201	262
Average	5.4	4.7	5.3	6.9
Median	6	5	6	7
Dispersion	5.5	5.6	4.7	56

The data in this table were collected by the “Pedagogical Statistics” program for the analysis of

data obtained as a result of pedagogical research (Lipovtcev,2004). The authors conclude that the mean for the normal law of normal distribution is the same as the median, and for the median law of normal distribution. Therefore, nonparametric abnormal distribution methods should be used to identify differences in the experimental and control groups.

The authors analyze the source data using the statistic criterion  $\chi^2$  in the table of data frequency grouping. This criterion is used to compare the distribution of two sets. To use this criterion, the following requirements must be met: 1) two samples are randomly selected; 2) the samples are independent and each member is independent; 3) scale of several categories (s). This research data meets all these requirements. Therefore, this criterion can be used.

The grades for the experiment and the control groups were divided into four categories (2,3,4,5). The degree of freedom of this distribution is C

= L -1 = 3. The number of the first sample  $q_{1i}$ , where the i-category of state ( $i = 1,2,3,4$ ) is located, and the number of objects in the second sample is determined. The authors determine the probability that a randomly selected object from the first set falls into the measurable category of property ( $i = 1,2,3,4$ ) and the probability that such an event is possible for objects of the second set. Then the null hypothesis of the equality of probability of falling into each category of objects  $i$  of the first and second sets from the table (Table 10), which grouped the source data on a scale of frequency-frequency sequences, is considered. Thus, the null hypothesis  $H_0$  is performed for all categories  $C = 4$ , and for at least  $p_{1i} = p_{2i}$ , one category C the alternative hypothesis is  $H_1$ .

To test the null hypothesis above using the criterion, the statistical value T of the criterion  $\chi^2$  based on the data in table 10 using the following formula is calculated ( $n_1$  and  $n_2$  are the sample sizes):

$$T = \frac{1}{n_1 \cdot n_2} \sum_{i=1}^C \frac{(n_{1i}q_{2i} - n_{2i}q_{1i})^2}{q_{2i} \cdot q_{1i}} \quad (1)$$

**Table 10**

*The value of the criterion  $\chi^2$*

Assessment	CG	EG	$T_j$
0-50	4	2	0.67
50-74	11	6	1.48
75-89	19	17	0.11
90-100	4	13	4.8
Addition of value T:			7.6

Critical  $\chi^2_{0.05}$

Values 0,05 of criteria  $\chi^2$  are in Table 11.

**Table 11**

*for criteria  $\chi^2_{0.05}$  of significance level*

$\chi^2_{0.05}$	1	2	3	...	9
L -1	3.84	5.99	7.82	...	16.92

$\chi^2_{emp} = 7.6 > 5.99 = \chi^2_{0.05}$ , which means that “at the end of the experiment, the difference between the characteristics of the experimental and the control group was 95%.” Finally, the initial (pre-experimental) states of the experiment and the control groups coincide. And the last (after the

experiment) states do not coincide. However, the authors conclude that the change was the result of an experimental teaching methodology.

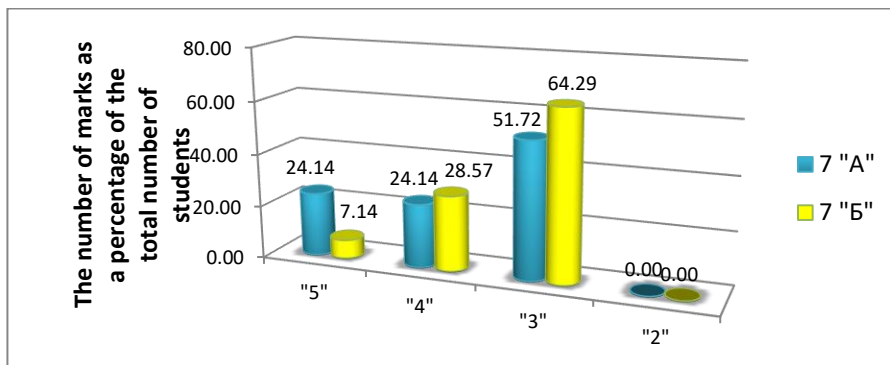
Analyze the Wilcoxon-Mann-Whitney criterion. This criterion is used to determine how the property in question is distributed across two sets. This criterion is also critical, it is equal to  $W_{0.05}=1.96$ . The result of the calculation is called  $W_{emp}$ . If the empirical value obtained by us exceeds the critical value, then the initial (pre-experimental) state of the experiment and the control group will be the same. And the last (after the experiment) states do not coincide. However, the author concludes that the change was the result of an experimental teaching methodology.

The authors compare this empirical value with the critical  $W_{emp}= 3.76 > W_{0.05}=1.96$ . However, the accuracy of differences in the characteristics of the compared samples is 95%. That is, it can be concluded that the change was the result of experimental learning techniques. This result was obtained as a result of relevant experimental data and application of the  $\chi^2$  Wilcoxon-Mann-Whitney criterion. And also, Figure 3a presents a chart of the results of the interim assessment (for 1 quarter) of students in grades 7th "A" and 7th "B". Pupils of the 7th "A" class in

which the experiment took place showed better results. Figure 3b presents a diagram reflecting the dynamics of the educational results of the 7th "A" class: the results of initial diagnostics and interim assessment (for 1 quarter). The number of students who received "5" increased significantly, there are no students who received "2", due to which the number of "3" and "4" did not change much. It is possible to talk about the positive dynamics of educational success of students of the 7th "A" class in which the experiment took place.

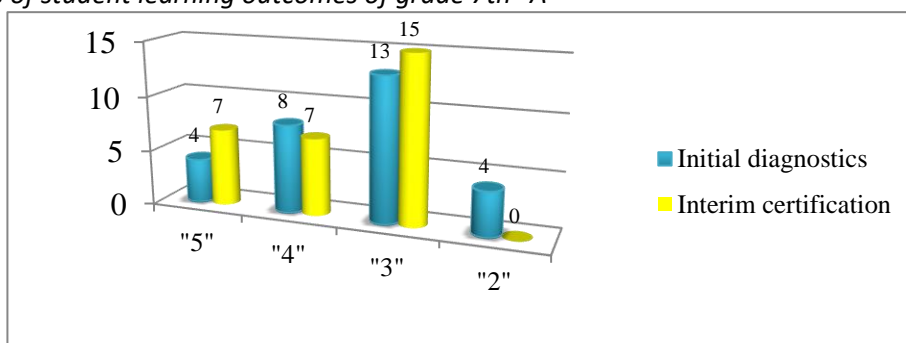
**Figure 3**

a) results of interim assessment of students in 7th grades



A

b) dynamics of student learning outcomes of grade 7th "A"



b

In addition, the use of various criteria-based assessment methods using the functional literacy assignment found positive feedback from participants in the educational process: parents note the

transparency of their children's grades and a clear understanding of what gaps need to be filled in the future, students know what they will need to do to get a grade they want, anxiety decreases and motivation of students increases, positive feedback on the development of students is given by the class teacher and subject teachers, works in the 7th "A" grade. The data presented suggest that the use of tasks based on functional literacy contributed to more effective teaching of computer science for students in 7th grade.

#### **4. Discussion**

The results of the study demonstrated, first, that teachers renamed their educational discourse about learning assessment significantly, increasing it in assessment for learning practices, particularly in the themes of timing and agents, and reducing it in all themes referred to the assessment of learning practices. And second, three clusters of faculty were identified, which differed in terms of the way they merge both learning assessment practices: professors with a slight prevalence of the assessment for learning conceptual voice, professors with a slight prevalence of the assessment for learning practical voice, and professors with a strong prevalence of the assessment for learning voice (Sagimbayeva, Zaslavskaya, and Avdarsol, 2020; Stambekova et al., 2021).

The criteria-based approach to assessing students consists in comparing the students' achievements with well-defined, collectively developed, criteria well known to all participants in the process. Evaluation criteria are developed for each subject. With proper preparation of the criteria scale, a student can independently assess the quality of their work, which stimulates the achievement of a higher educational result and the formation of educational independence (Uaidullakzy, 2021). The application of the criteria-based approach in the educational system makes it possible to identify and improve the system for assessing student performance with the objective goals of an individual subject, as well as using certain parameters (criteria) that allow students to compete in high school.

#### **5. Conclusions**

The study of criteria-based assessment as the basis for the formation of students' functional literacy in computer science and the results of experimental work has led to several conclusions:

1. Criteria-based assessment helps reduce student anxiety and form a positive motivation. The fact that grades obtained for intermediate work are not put up in a journal makes this work a meaningful activity to build up knowledge. A teacher is transformed from a severe judge to a concerned assistant and consultant. Between a teacher and a student, the conflict zone disappears, and assessment becomes a joint work according to the criteria adopted by both parties.
2. The basic content of education involves objective results aimed at enhancing the functional, including the practical, focus of training. Despite the different number of points in the assessment and the divergence of opinions on this issue in different countries, in all of these systems, the unifying core is the criterion of assessment and the differentiation of the levels of assimilation of educational material by students.
3. The process of developing functional literacy of students using the assignment determines the introduction of a new assessment system that takes into account the effectiveness of all types of educational activities, the procedural side of learning material, and the manifestation of individual and personal qualities of students
4. When studying in the elementary school (7–10th grades) the same program material for a different period, depending on individual abilities, by the end of the 10th grade, students should achieve the same learning goals. This approach to the organization of the educational process gives a high learning outcome, and in the future leads to successful adult life.
5. The system of criteria-based assessment using the task of functional literacy allows to receive integral and differentiated information about the educational process, track the individual progress

of students in achieving the planned results, provide feedback for teachers, students, and parents, and monitor the effectiveness of the educational program.

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