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# Formation of information-intellectual competence of future teachers of computer science

**Perizat Seisenbekova***, Al-Farabi Kazakh National University, Faculty of Information Technology, Department of Computer science, Al-Farabi 71 ave., Almaty, Kazakhstan https://orcid.org/0000-0002-3827-7545

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**Abstract**

This article discusses the work of teachers who study competencies. The formation of information-intellectual competencies of future computer science teachers in the context of digitalization is considered. As a result of the study: the structure of the information-intellectual competence of the coming computer science teacher is theoretically substantiated and the definition of information-intellectual competence is given. We have identified the components that form information-intellectual competence: linguistic competence, algorithmic competence, deductive competence, inductive competence, and informational competence. The forms and methods of teaching for the development of information-intellectual competencies of future computer science teachers are presented. Experimental work was carried out by teaching-learning tasks for the formation of information-intellectual competencies for prospective teachers of computer science. The experimental work was carried out according to the independent Student's t-test. The results of the study confirmed the effectiveness of the experimental work on the independent Student's t-test and confirmation of the hypothesis.

**Keywords:** information-intellectual, algorithmic competence, linguistic competence, teaching methods, knowledge digitization.

* **Perizat Seisenbekova,** Al-Farabi Kazakh National University, Faculty of Information Technology, Department of Computer science, Al-Farabi 71 ave., 050040, al-Farabi Ave., 71, Almaty, Kazakhstan,
Email address: ms.perizat@mail.ru / Tel: 8-7071039979

## 1.Introduction

### *1.1. Conceptual or Theoretical Framework*

The current digitalization process is affecting all countries of the world. Therefore, foreign countries are determining their own digital development priorities. Many countries of the world are implementing national digitization programs. Among them, many issues that need to be solved within the framework of the "Digital Kazakhstan" state program are being carefully studied in our country. One of the issues mentioned in this program is that every teacher in the country should not only have knowledge in the field of information and communication technologies but should also be a professional who widely uses digital technologies in his professional activities at school.

Kazakhstan is implementing the program "Digital Kazakhstan" for the years 2018-2022 (State program "Digital Kazakhstan", 2017). Formation of information- intellectual competencies of future computer science teachers by making a small contribution to the implementation of the «Digital Kazakhstan» program in the field of education. The "Dictionary of methodological terms" says: "Competence is a set of knowledge, skills, and abilities formed in the process of teaching a subject, as well as the ability to perform any task." The concept of competence is multifaceted concept. It can be concluded that if there is an innovation, it will inevitably have competence.

### *1.2. Related Research*

In the research works of teachers Zimnyaya I. A., Zakirova R. A., Zhumash Z., Trishna S. T., Ponomarenko L. N., Zlobina I. S., Galitsky E. O., Rubleva O. S., and other teachers, competence is considered as a result of education (Zimnyaya I.A., 2003; Zakirova, R. A., 2016; Zaitseva O.B., 2002; Zhumash Z. et.al., 2021; Masrur, 2021; Ponomarenko L.N. et.al., 2017). The works of many researchers and teachers are devoted to the topic of competence, among them can be noted the study of Kudaibergenov K.S. (Kudaibergenova K.S., 2012) dedicated to the theoretical foundations of the formation of information competencies of students in the country, Isabayeva S.N. (Isabaeva S.N., 2010) pedagogical conditions for the formation of the foundations of information competencies of students, formation of students' competencies (A.Temirgalinova et.al., 2021). This study aims to investigate the possibility of the formation of professional competence based on distance learning programs (Zaidin, M., Kusmaladewi, K., & Thaba, A., 2021). Russian scientists L.E. Panfilova, T.E. Matveeva, S.A. Sapon, and O.V. Filimonova in their works provide the formation of information-intellectual competence of schoolchildren, defining the concept of information-intellectual competence, theoretically and experimentally substantiating the developing education system (Panfilova L.G. et.al., 2010; Filimonova O.V., 2016)

Thus, summarizing the views of various researchers, we define competence as the achievement of acquired knowledge, skills, abilities, and learning activities aimed at the effective achievement of goals in a particular education system. And information competence was defined as the ability to use knowledge, skills, abilities, and information technologies obtained in the learning process.

### *1.3. Purpose of the Study*

The intellectual competence of a future computer science teacher will be considered «a special type of knowledge organization that provides the ability to make effective decisions in a particular subject area». Since intelligence determines the success of any activity, we believe that intellectual competence is the key to other competencies and will play a key role in shaping the informational and intellectual competence of future computer science teachers.

Information-intellectual competence is the effective use of the information received for the optimal solution of problems and tasks of educational and cognitive activity. Despite the differences in information-intellectual skills, they are closely interrelated. Information competence is focused on the collection and processing of information, intellectual competence is focused on the production and creation of new knowledge. Within the framework of the educational process, this information-

intellectual activity is defined by the concept of «Information-intellectual competence», which is interpreted as the optimal solution to issues and problems in educational and practical activities based.

The purpose of the experimental work is to check the correctness of the proposed hypothesis, as well as to evaluate the effectiveness of the methodology of teaching the basics of artificial intelligence based on the formation of information and intellectual competence of the future computer science teacher.

## 2.Materials and Methods

### *2.1. Research Model*

Since information-intellectual competence is the result of education in accordance with modern standards, its formation in the process of educational and cognitive activity is reflected in the level of information-intellectual abilities of future computer science teachers in higher education. They should be considered as the goal of the educational process. Information-intellectual competence develops information and intellectual skills. The components that form the information-intellectual competence of the future computer science teacher are revealed. These components are the components that form the information-intellectual competence of the future computer science teacher. Let's give a definition for each component:

Linguistic competence is a personal quality characterized by a set of knowledge, skills, and abilities that allow a future computer science teacher to receive, understand and memorize messages containing information presented in natural language. In the structure of the language competence of the future computer science teacher, two components can be distinguished. Firstly, knowledge of special terminology is necessary and sufficient for a complete and accurate description of the specialty subject. Secondly, the ability to identify the main features and connections of the relevant scientific concept, arising from the gained knowledge.

Algorithmic competence - in general, as an integral part of the information-intellectual competence of the future computer science teacher, demonstrates the ability to manage his cognitive and professional activities from solving problems to achieving the desired result. Deductive competence is manifested in determining the type of problem, analyzing its state, determining the method of solving, and testing. Knowledge is characterized by knowing the general laws of logic, which allows for drawing logical conclusions. Inductive competence is systemic knowledge that allows generalizing, systematizing, and finding solutions to situations, evaluating the results of work, and looking at it from different sides. Information competence is the ability to use knowledge, skills, and information technologies obtained in the learning process.

We offer a teaching methodology by components that form the information-intellectual competence of future teachers of computer science. In order to form the information-intellectual competence of future computer science teachers in terms of the linguistic competence component, we considered: knowledge mobility, the flexibility method, and the criteria for critical thinking. This competency component includes lectures and seminars. Lectures consist of video lectures, presentations, and a file with the full text of the lecture. Lectures are asynchronous. In an intellectual environment, a student can independently watch, read and write notes of video lectures. Seminars are held in the form of webinars to answer questions regarding the lecture topic. Students prepare questions for the previous lecture and ask each other for answers, and at the end are automatically graded through passing a test and written answers.

At this stage, students learn from lectures and pass on their knowledge in the seminar class orally, through testing and writing.

Knowledge assessment is carried out according to three criteria.

- The ability to find the right information, and the ability to interpret information from the mobility of knowledge.

- The flexibility method organizes the use of information in different situations. Transforming information, seeking evidence, and making decisions forms critical thinking.

The result of this stage is the self-determination of the future computer science teacher, based on the desire to learn the material, feel the need to study it, and set important personal goals for the activity. The algorithmic component of competence is reflected in the performance of laboratory work. It is necessary to create conditions for future teachers of informatics to perform tasks that connect their theoretical knowledge with life. That is, students, collect information in the learning process and further develop their knowledge not only through knowledge and understanding but also through analysis, synthesis, evaluation, and its comprehensive application. Laboratory work is performed and evaluated on a computer in computer classes. Laboratory work is divided into levels. The student is allowed to perform laboratory work at his level with the score gained as a result of the 1st stage. For example, a student who scores between 100 and 90 immediately completes a Level A task. Students who score 89-70 are at Level B, and students who score the remaining 69-50 are at Level C. A student who completes level A can further develop their own project. Students scoring at levels B and C are only allowed to create their own projects when they reach level A. Permission is granted automatically in the intelligent environment. In this section, a teacher only evaluates.

Deductive competence (student's independent work (ISW)).

This level is a theory and practice of organizing the search for inventions in solving complex information-intellectual competencies, which considers the laws of creative activity of the student, a method of teaching through intellectual questions. At this stage, students in groups of two or three students prepare and defend a presentation on a given topic. Questions are assessed by teachers and students.

Inductive competence (student's independent work with the teacher (TSIW))

Action in the pedagogical process appears as a response to any situation. The method of action is chosen individually or collectively at the discretion of the future computer science teacher and organizes itself to perform a situational task. Self-organization includes planning, implementation, and solution.

The future teacher of computer science must have basic knowledge, quick reaction, developed imagination and intuition, and then be able to implement decisions. At this stage, an abstract on the topic is written and uploaded to the intellectual environment. The teacher checks and evaluates. Works that are not uploaded on time will not be accepted in an intellectual environment. The result of this stage – is the performance and presentation of situational tasks.

Information competence is a component of information-intellectual competence, which is reflected in the projects developed by future teachers of computer science through the knowledge, skills, abilities, and comprehensive use of information technology in the learning process. The result of this stage – is to present their project based on the acquired skills (Shayakhmetova A.S. et.al., 2020)

While working on the project, the future computer science teacher develops the ability to independently plan activities, time, and resources, make individual decisions and make their own choices. Today, in the process of digital education, digital educational technologies (combined learning, mobile learning, gamification, distance learning technologies, electronic (online) training, etc.) technical means and specialized interactive equipment (PC, laptop, tablet, robot set, interactive whiteboard, electronic flip chart, interactive panel, interactive sandbox, interactive floor, interactive cubes, etc.).

Table 1 shows the components that form information-intellectual competence. This table presents the components of information-intellectual competence, which should be done in order to become competent, and the level of assessment.

Table 1. Components of information-intellectual competence

| Components of information-intellectual competence | Content | Levels of definition of information-intellectual competence | Information-intellectual competence | Level assessment |
|---|---|---|---|---|
| Linguistic competence | Lecture | Video lecture<br><br>Presentation lecture<br><br>Lecture notes | Must be able to read and understand information on their own. | Supporting abstract<br><br>*score 10* |
| | Seminar | Mobility of knowledge<br><br>The learner's curiosity and ability to explain and convey what they know increases. | Must be able to find the necessary information on their own and explain the information. | (... who, ... what, ... when, ... what is the meaning, ... what is the main idea, ... name the keyword, ... give a definition, ... write the formula, ... .write the property, ... describe, ... find in the dictionary), questions 1 - 10.<br>*score 30* |
| | | Flexibility method<br><br>The learner develops flexibility, the ability to quickly adapt to any situation. | Must be able to use information in different situations. | (... how, ... why, ... why, ... what it consists of, ... how it relates, ... what are the differences, ... give an example, ... solve it by different methods, ... create a root summary), questions 11 - 20.<br>*score 30* |
| | | Critical thinking<br><br>The student's self-confidence and courage increase. | Must be able to modify information, find evidence, put their thoughts into action and make decisions. | (... find the mistake, ... why, ... what are the criteria, ... what are the advantages and disadvantages, ... make predictions, ... give arguments in favor or against), questions 21 - 30.<br>*score 30* |
| Conclusion | | 10+30+30+30=100 | | score 100 |

| | | | |
|---|---|---|---|
| Algorithmic competence | Laboratory work | A student who has scored between 100-90 will immediately complete a Level of A task<br>The student from 89 to 70 performs the task of level B.<br>In the range of 69-50 points, the student performs at level C. | Level A.<br>A student who has completed level A can further develop their own project.<br>Students are only allowed to create their own project when they reach Level A from B.<br>Level C.<br>Students are allowed to create their own project only if they perform at levels B and A. |
| Deductive competence | Student's independent work with the teacher (TSIW) | At this stage, according to the plan, an abstract is written and uploaded to the intellectual environment. | The teacher checks and evaluates. |
| Inductive competence | Student's independent work (ISW) | At this stage, students in groups of two or three students prepare and defend a presentation on a given topic. | Questions are assessed by teachers and students. |
| Conclusion | 100+100+100=300/3 | | score 100 |
| Information competence | Creating a project | Projects will be developed and defended on selected topics. | |
| Conclusion | 100 | | score 100 |
| General conclusion | 100+100+100=300/3 | | score 100 |

Methods and techniques used in teaching future teachers of computer science task «Identification» (The program is written into parts, divided into parts, arranged in sequence according to the algorithm) «Mobile logic» (what will be the task if this is a program or a question if this is an answer?) "Association" method (description of the main properties with keywords) «Case study» method (questions and solutions) «Project» method (it is recommended to develop and protect the project).

*2.2. Participants*

In the context of digitalization, education means not only technical innovations but also changes in the structure of the University and the content and organization of educational courses. The structure of education and the organization of the educational process leading to changes in the formation of digital learning. These changes are a big problem for the completion of training courses and for the organization and management of the university. It is not enough to digitize educational materials to digitize the education system. Criteria for assessing the student's knowledge - should be

useful for the student. Innovations in the content and structure of lessons, and organizational and structural changes in the university should be useful to students.

A project-based approach to teaching, innovative modernization of educational programs, motivation of each student to create their own projects, and development of startups - are the main tasks for the university. Recently, there has been an active process of creating and using open general education, and online learning resources in pandemic conditions, from level tasks to courses and modules for the formation of assigned competencies. A single platform of online courses allows students to quickly adapt to information-intellectual competencies, evaluate information, and make decisions in special cases.

The experiments were conducted in an online format during the pandemic. 8 students of the first group of the 3rd year group of the University were included in the experimental study as an experimental group, and 8 students of the second group as a control group. A total of 16 students participated in the experimental study. Lectures on the formation of information-intellectual competencies of future teachers of computer science were conducted on the online platform ZOOM, learning tasks on the telegram channel (Fig 1, 2).

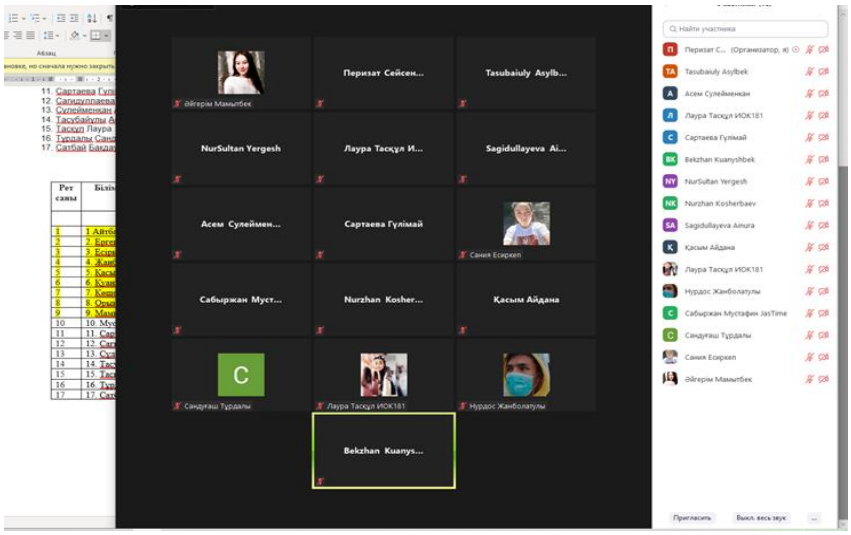



Fig 1. Lectures on the ZOOM platform

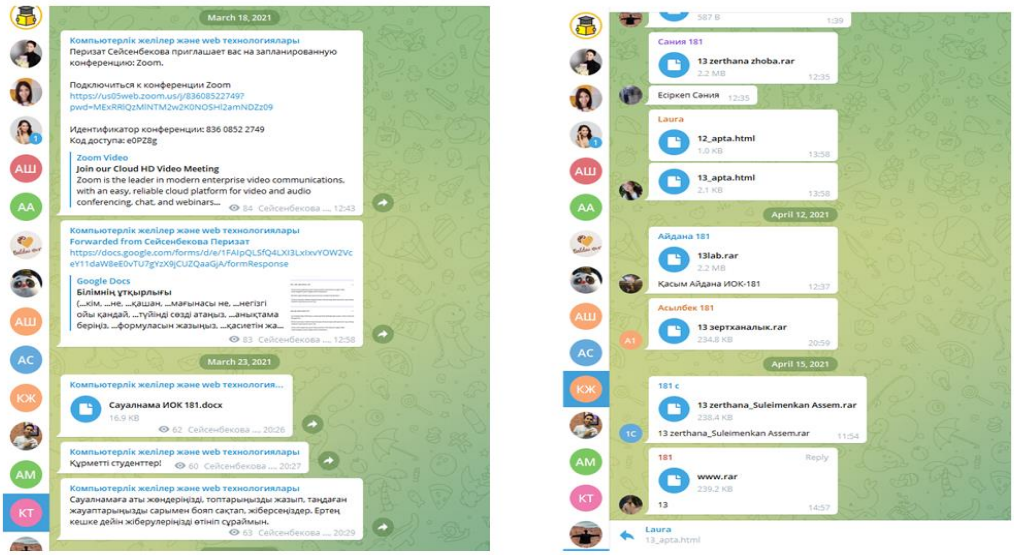



Fig 2. Reading tasks on the telegram channel

One of the main directions of education in the context of digitalization is network services, the use of social networks as educational resources, and online classes, and training. Features of digital education in the use of network technologies - flexibility, mobility, productivity, dialogue, and interactivity, focus on the reception of media flows. All this contributes to the formation of information-intellectual competence.

*2.3. Data Collection Tools*

Research methods: thoroughly analyze, collect, and summarize pedagogical and methodological literature, analyze and systematize educational programs and syllabuses on the basis of artificial intelligence; survey, and test methods, and conduct an examination of previous high-level experience.

In the course of the research, a set of mutually complementary methods was used: the method of theoretical analysis is a comprehensive study of the situation of the problem under consideration, determination of the extent of its research and its solution, identification of a set of pedagogical conditions for the analysis of pedagogical practice, study, generalization, systematization, observation, conducted for a survey, testing, research, and generalization purposes. In order to evaluate the effectiveness of teaching the basics of artificial intelligence based on the formation of the informational and intellectual competence of the future computer science teacher, a pedagogical experiment was carried out, which involved teaching in experimental and control groups. Mathematical statistics methods and specially developed test tasks were used for comparative diagnosis of students' level of education.

*2.4. Data Collection Process*

The course "Fundamentals of artificial intelligence" is one of the main courses taught in the training of future computer science teachers. This course is taught to future teachers in the amount of 5 ECTS.

The experiment was conducted in three phases.

In the first, decisive period (2018-2019) - the state of the research problem was analyzed, the problems of teaching the basics of artificial intelligence during the training of future computer science teachers in domestic and foreign studies, and the training of the basics of artificial intelligence based on the formation of the information-intellectual competence of the future computer science teacher the need was determined.

In the second stage of the experimental work, a formative experiment was conducted (2020-2021) - based on the formation of the information-intellectual competence of the future computer science teacher, the result of introducing the methodology of artificial intelligence into the educational process was clarified. The work on the formation of the information-intellectual competence of the future computer science teacher was implemented.

In the third (2021-2022) - control period, the results of the experiment were drawn, the results of the methodology of teaching the basics of artificial intelligence based on the formation of the information-intellectual competence of the future computer science teacher were summarized and its processing was developed.

*2.5. Data Analysis*

Future computer science teachers, whose information-intellectual competencies are formed through learning tasks:

- know the necessary and sufficient special terminology to fully and accurately describe the object of the specialty;

- be able to identify the main features and connections of the relevant scientific concept arising from the acquired knowledge;

- able to demonstrate the ability to manage their cognitive and professional activities from the task to the desired result;

- know the general laws of logic, which allows drawing logical conclusions;

- be able to generalize, systematize and apply systematic knowledge, which allows to find solutions to situations, evaluate the work done, and appear in different forms;

- be a person who is able to fully apply the knowledge, skills, abilities, and information technology acquired in the learning process.

A person is a person who is able to set goals for himself, act independently and systematically, develop independently, be responsible for his own actions, to live a full life with a very high level of human and professional (Noskova T.N.et.al., 2018).

The development and implementation of the proposed teaching methodology allow for the formation of informational and intellectual competence of the future computer science teacher in the field of artificial intelligence. Based on the formation of information and intellectual competence of the future computer science teacher, the effectiveness of teaching the basics of artificial intelligence will increase, and the quality of education will increase.

**3.Results**

The method of control was widely used in the experimental work, the value of which is the ability of the object of study to be a natural perception, independence from the participants, to assess the individual consequences of the measures taken. The first stage (definition) studied the state of the problem in theory and pedagogical practice. 8 students of the first group of the 3rd year group of the University were included in the experimental study as an experimental group, and 8 students of the second group as a control group. A total of 16 students were involved in the experimental work. It allowed a full-fledged, natural pedagogical experiment. Probabilistic-statistical methods were effective in evaluating the results and conclusions of the experiment.

In the course of the experiment, we calculated the independent Student's t-test to compare the information-intellectual competencies of future computer science teachers of the experimental group and the control group.

Step 1. Table 2 - Enter the values of the experimental and control groups.

| Experimental Group | | Control group | |
|---|---|---|---|
| Full Name | Score | Full Name | Score |
| Student 1 | 93 | Student 1 | 76 |
| Student 2 | 83 | Student 2 | 65 |
| Student 3 | 91 | Student 3 | 80 |
| Student 4 | 88 | Student 4 | 76 |
| Student 5 | 91 | Student 5 | 81 |
| Student 6 | 96 | Student 6 | 83 |
| Student 7 | 81 | Student 7 | 50 |
| Student 8 | 76 | Student 8 | 45 |

*Step 2.* We use the *Student's t-test* for independent groups to compare the mean values of the two independent groups.

Terms of use:

1. Compared values cannot form a correlated pair

2. The distribution of symbols in each group corresponds to the normal distribution

3. *The variances of the differences* in the groups are approximately equal (checked by the F-Fisher test)

Student's t-test for independent groups:

$$t_e = \frac{|M_1 - M_2|}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

where $M_1$— is the arithmetic mean of the first group; $M_2$— arithmetic mean of the second group; $\sigma_1$— standard deviation of the first group; $\sigma_2$— standard deviation of the second group; $n_1$— number of students of the first group; $n_2$— number of students of the second group.

Step 3. The arithmetic mean is the sum of all the values in the distribution divided by their number. We determine the arithmetic mean by the following formula.

$$M_x = \frac{\sum x_i}{n}$$

$$M_1 = \frac{93 + 83 + 91 + 88 + 91 + 96 + 81 + 76}{8} = 87{,}38$$

$$M_2 = \frac{76 + 65 + 80 + 76 + 81 + 83 + 50 + 45}{8} = 69{,}5$$

Step 4. *The standard deviation* is the positive square root of the variance.

Because the variance is measured in squares of the original units, researchers have difficulty interpreting it. For the convenience of explaining the variability of the data, a standard deviation is used, the variability of which is reflected in the values of the original units.

*Standard deviation formula:*

$$\sigma_x = \sqrt{D_x} = \sqrt{\frac{\sum(x_i - M_x)^2}{n - 1}}$$

$$\sigma_1 = \sqrt{45{,}98} = 6{,}78$$

$$\sigma_2 = \sqrt{215{,}71} = 14{,}68$$

Step 5.

Table 3

Calculate according to the Student's t-test for independent groups.

| № | Scores of experimental (E) and Control (B) groups | | Deviation from the mean | | Square deviation | |
|---|---|---|---|---|---|---|
| | Э.1 | Б.2 | Э.$x_i - M_1$ | Б. $x_i - M_2$ | Э.$\sqrt{D_1}$ | Б.$\sqrt{D_2}$ |
| 1 | 93 | 76 | 5.62 | 6.5 | 31.5844 | 42.25 |
| 2 | 83 | 65 | -4.38 | -4.5 | 19.1844 | 20.25 |
| 3 | 91 | 80 | 3.62 | 10.5 | 13.1044 | 110.25 |
| 4 | 88 | 76 | 0.62 | 6.5 | 0.3844 | 42.25 |
| 5 | 91 | 81 | 3.62 | 11.5 | 13.1044 | 132.25 |
| 6 | 96 | 83 | 8.62 | 13.5 | 74.3044 | 182.25 |
| 7 | 81 | 50 | -6.38 | -19.5 | 40.7044 | 380.25 |
| 8 | 76 | 45 | -11.38 | -24.5 | 129.5044 | 600.25 |
| Summary: | 699 | 556 | -0.04 | 0 | 321.8752 | 1510 |
| Average value: | 87.38 | 69.5 | | | | |

$$t_e = \frac{[87{,}38 - 69{,}5]}{\sqrt{\frac{6{,}78^2}{8} + \frac{14{,}68^2}{8}}} = \frac{17{,}88}{5{,}72} = 3{,}1$$

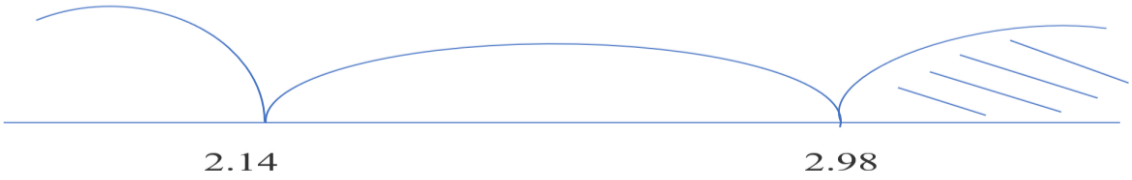
*Result*: $t_e = 3.1$

*Step 6. Conclusion.*

Student's t-criterion for independent groups is equal to $t_e$= 3.1 and the value of Student's t-criterion in the table is p = 0.05

Table 4 - Critical values:

| $t_{\text{см}}$ | |
|---|---|
| p≤0.05 | p≤0.01 |
| **2.14** | **2.98** |




*An unimportant area* *An important area*

**Fig 3.** Axis of importance

The obtained empirical value of t (3.1) is in the critical region. Therefore, the difference between the arithmetic mean of the two statistical groups is statistically significant.

**4.Discussion**

The obtained results show that the knowledge of future computer science teachers in the experimental group is high. In addition, the results of mathematical and statistical analysis of the experimental study showed the statistical significance of the differences between the arithmetic mean of the results obtained in the experimental and control groups. The results of the study confirm the effectiveness of the experimental work and the confirmation of the hypothesis.

The following methods were used to diagnose information-intellectual competence:

- Questionnaire of A. Pakulina and SM Ketko «Determining the motivation of students of pedagogical universities to study».

- Questionnaire «Attitude of future teachers of computer science to information-intellectual competence» developed version of the methodology of N.A. Shamelkhanova (Zhexembinova A.K. et.al., 2016).

Based on the results of the formative experiment, we observed a positive trend in the motivation of students to learn. This means that the proposed content of the subject «Fundamentals of Artificial Intelligence» will increase the interest of future computer science teachers in education. As a result of a survey conducted on the developed version of the method of N.A. Shamelkhanova,

we noticed how much the attitude of students to information-intellectual competence has changed. There was a sharp decline in baseline (-7.96%), an increase in service (5.96%), and an increase in advanced (2%) levels, and in the control group, despite the positive dynamics at the initial and service levels, we found that the advanced level remained unchanged. The results of this survey show the effectiveness of the work and the confirmation of the forecast.

**5.Conclusion**

Research has been conducted on the work of many teachers on the formation of information-intellectual competencies for future teachers of computer science. The formation of information-intellectual competencies of future computer science teachers in the context of digitalization was considered. As a result of the study: the definition of information-intellectual competence was given. Forms and methods of teaching were considered, identifying the components that form the information-intellectual competence. Experimental work was carried out on the independent Student t-test. Irrespective of the results obtained in the study, the effectiveness of the experimental work on the Student t-test and the confirmation of the hypothesis was confirmed. Educational responsibility should be assigned to the first student. «Read whenever you want, wherever you want, as much as you want, and be responsible for your own actions». The teacher, on the other hand, should provide guidance and counsel when needed. If we teach the future teacher of computer science to live within their abilities, to realize their inner potential and their abilities, search skills, perception of information, and intellectual thinking. Only then will we instill information-intellectual competence in the future teacher of computer science.

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