THE CONTINUITY OF THE STUDY ON THE TOPIC "COMPLEX NUMBERS" IN SECONDARY SCHOOLS AND IN PEDAGOGICAL UNIVERSITIES OF THE REPUBLIC OF UZBEKISTAN

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ABSTRACT

This article discusses the issue of continuity of the study of the topic "Complex numbers" in schools and pedagogical universities in connection with the reforms carried out in the field of education in the Republic of Uzbekistan, and changes in the content of secondary education, in particular mathematical education. It is necessary to develop methods for studying newly introduced sections of mathematics, especially some recurring topics, and to improve methods of teaching academic disciplines based on new educational technologies, taking into account modern requirements and international experience. In the course of the research, various research methods were applied, namely, the study and analysis of scientific and pedagogical, methodological, mathematical literature and school textbooks in mathematics; analysis of the continuity of the section "Complex numbers"; pedagogical experiment to test the residual knowledge of students on the topic "Complex numbers"; discussion of research materials.

Keywords: Continuity, Complex Numbers, Algebra and Number Theory, Mathematical Analysis, Theory of Analytical Functions, Level of Learning, Degree of Abstraction, Educational Element.

INTRODUCTION

The development of the information society puts its demands on the education system. These requirements apply both to educational content and to learning outcomes. The development of information technologies, pedagogical ideas, the results of international studies on education (TIIMS, PISA, etc.), the importance of the development of STEAM technologies determine the change in the content of school mathematical education. In this regard, new sections have been introduced in the school mathematics program of the Republic of Uzbekistan, such as combinatorics, elements of mathematical logic, complex numbers, elements of probability theories, elements of mathematical statistics, and financial mathematics. As a result, some topics or their contents, in particular the topic "Complex numbers", are repeated. The question arises: "Do I need to re-study at the university?" University teachers answer ―yes, because the knowledge and skills of yesterday‘s students in complex numbers do not meet the requirements of the university program. Naturally, questions arise of developing a methodology for studying the topic "Complex Numbers" at school and university. Therefore, ensuring the continuity of teaching mathematics in the school-university system is again becoming relevant. Scientific sources that examined the issues of continuity of teaching mathematics in the "school-university", "lyceum-university" systems [2, 3, 4] mainly examined the study of the foundations of mathematical analysis. In [9], to ensure the continuity of the study of basic concepts Analysis is offered through the intuitive introduction of the basic concepts of algebra and the principles of analysis in schools and pedagogical universities. And since complex

numbers have recently been introduced into the practice of a comprehensive school, the continuity of studying this topic in the school-university system has not been considered. To achieve the goal of our study, the works of R.M. Turgunbaev and I. Allambergenov [2, 3, 12, 13] were considered. In these studies, in order to ensure the continuity of the study of the basic concepts of mathematical analysis, repeating topics in the mathematics programs of academic lyceums and mathematical analysis of universities are analyzed, the topics are described in the educational literature and they compiled tables of learning elements that characterize the level of learning elements (α) and the levels of abstraction that characterize the language of presentation educational information (β) proposed by V.P. Bespalko [5]. Thus, they proposed their own of option of ensuring the continuity of the study of recurring topics at the academic lyceum and university.

In this article, we consider the issue of continuity of teaching and the content of the topic "Complex Numbers", which is studied in the 10th grade of secondary schools in higher educational institutions, in particular pedagogical universities of the Republic.

MATERIALS AND METHODS

It should be noted that in the new school programs in mathematics, the quality of learning elements of instruction is not indicated. For example, in the section "Complex numbers" of a program in mathematics it is indicated that "... can calculate the values of simple expressions with complex numbers" [6]. But there is no information about the complexity of these expressions.

According to the approved new program in the course of mathematics, it is planned to teach the topic "Complex numbers". The same topics are studied in higher education, in particular in the course "Algebra and Number Theory" undergraduate course "5110100-methodology of teaching mathematics". And also complex numbers are used in mathematical analysis (analytical functions). If we analyze the textbooks recommended for pedagogical universities [1, 7, 10, 11], we see that the concepts of complex numbers, arithmetic of complex numbers, and geometric interpretation are repeated. The question naturally arises, should a re-study of these materials be followed, if so, why and how. To answer this question, it is necessary to answer questions about what is the knowledge of first-year students on the topic "Complex numbers". In order to answer these questions, it is necessary to analyze the theoretical material and questions related to complex numbers. Also, to carry out the test work with first-year students who have entered the mathematical field, to analyze the results. It is also important to clarify the degree of students mastering material related to complex numbers by clarifying the teaching contexts of the disciplines "Mathematical Analysis", "Algebra and Number Theory".

First, consider the presentation of the topic "Complex numbers" in the schoolbook [8].

The 4th chapter of the school textbook is called "Complex Numbers" and 6 lessons are given for learning at the end of the fourth quarter of the 10th grade.

1-2 lessons are devoted to the topics "Complex numbers and actions on them" and "Images of a complex number." In these topics, the concept of a complex number is introduced, and related concepts: imaginary unit, real part, imaginary part of complex numbers, equality of complex numbers, arithmetic operations on complex numbers, opposite complex numbers, conjugate complex numbers, mutually inverse complex numbers; designations are introduced for complex numbers, the set of complex numbers, the imaginary unit, the real and imaginary parts, the conjugate complex number, the concept of the image of complex numbers in the coordinate plane, the complex number is the point of the plane, the complex number is the

radius vector, the concepts of the imaginary and real axis, geometric interpretation addition of complex numbers - the parallelogram rule.

These topics cover the following types of exercises and tasks: what are the real and imaginary parts of complex numbers; write complex numbers in algebraic form when the real and imaginary parts are given; indicate equal complex numbers; find the conjugate number in the given complex number; find the sum, difference, product and (go) quotient of complex numbers; plot complex numbers in a plane.

The 3-lesson provides information on complex numbers in trigonometric and exponential forms, in particular, the module of a complex number, the argument of a complex number, the area of the value of the module and argument; the recording form of the trigonometric and exponential forms of the complex number, it should be noted that the Euler formula is not introduced.

The following types of exercises and tasks are offered: find the module of a complex number; find the argument of a complex number; write down the complex number in trigonometric and exponential forms.

The next two lessons are devoted to the subject of the product and the quotient of complex numbers given in trigonometric form. In this topic, without proof, the formulas for the product and division of complex numbers given in the trigonometric form, raising to the natural degree of the complex number, and the Moire formula are given. Exercises and tasks on multiplication, division, raising to the power of complex numbers given in trigonometric form are considered; to perform an action where the use of trigonometric forms of complex numbers is required.

The next lesson is about extracting the square root of a complex number. We prove the formula for extracting the root of a complex number given in trigonometric form. A formula for extracting roots in degrees 3 and 4 is given without proof. The exercises and tasks of extracting the square root of a complex number are given. Chapter 4 contains 8 types of exercises, a total of 55 exercises. All of them can be used to organize the mathematical activities of students.

4-module of the curriculum of the discipline "Algebra and Number Theory" direction "5110100- methodology of teaching mathematics" [15] is called "Algebraic systems". His 11th and 12th topics are devoted to the study of the field of complex numbers, the modulus and argument of complex numbers, and their properties; the geometric meaning of a complex number, the trigonometric form of complex numbers, the Moiré formula, extracting the root of the nth degree from unity and an arbitrary complex number, axiomatic theory of complex numbers. To study these topics, 8 hours of lecture, 8 hours of practical training and 12 hours of independent work are allotted.

The 16-module of the curriculum of the discipline "Mathematical Analysis" of the direction 5110100-methodology of teaching mathematics [14] is called "Theory of analytic functions". In its topic "Complex plane", it is planned to study the concepts of the set of complex numbers and the isomorphism of this set with the Euclidean plane, as well as the concepts of a flat line and areas in the complex plane.

An analysis of the textbooks used to study complex numbers at school and university shows that complex numbers are taught in school mathematics from the point of view of expanding the concept of numbers, the presentation of topics and task material are aimed at forming the

procedural knowledge of students. And in the course "Algebra and Number Theory" complex numbers are studied as a numerical system - the mathematical basis of the future theory of polynomials and the theory of analytic functions. The set of complex numbers is a field, further studied polynomials over the field of complex numbers. The course of mathematical analysis considers complex numbers as numerical systems, their geometric interpretation, introduces the concept of a complex plane, continuous curves and domains in a complex domain, studies its topological properties, analytical functions and their properties. Note that in this course we prove the basic theorem of algebra, Euler's formula, and also give a final solution to the question of the degree of a complex number - an arbitrary degree of an arbitrary non-zero complex (in particular real) number is determined.

RESULTS AND DISCUSSIONS

Obviously, the study of complex numbers as an object of an algebraic system should be based on students' knowledge of complex numbers studied in the school course of mathematics. And the knowledge gained in the course "Algebra and Number Theory" will be used and supplemented in the analytical functions section of the course of mathematical analysis. An experimental study was conducted to assess the residual knowledge of freshmen students on the topic of complex numbers, studied at school, in vocational colleges or schools. It was held in October 2019 at the Ferghana State University. The experiment was attended by first-year students. Students were offered tasks similar to those at the school level of mathematics. Below is one of the options for writing.

№1.Show equal complex numbers: 1)$2-4i$; 2)$2+3i$;; 3)$\frac{2}{3}+i$ 4)$\sqrt{121}-7i$; 5)$33+44i$; 6) $\sqrt[3]{8}+\sqrt[3]{27}i$;

№2. Find the conjugate complex number z to a given number: $z=5-3i$;

№3. Find the amount:$(-5+3i)+(2-i)$;

№4. Find the difference:$(3+4i)-(4+2i)$;

№5. Find a product: $(4+6i)\cdot(3+4i)$;

№6. Find private:$\frac{2+2i}{1-2i}$;

№7. Follow the steps:$\frac{(3-4i)(4-3i)}{2+i}$;

№8. Draw a complex number on a plane: $z=3+4i$;

№9. Find the modulus of a complex number: $z=1+\sqrt{3}i$;

№10. Find the argument of a complex number: $z=\frac{\sqrt{3}}{2}+\frac{1}{2}i$;

№11.Write a complex number in trigonometric and exponential forms:$z=\sqrt{2}-\sqrt{2}i$;

№12. Find a product: $z_1=-\frac{\sqrt{3}}{2}\left(\cos\frac{\pi}{4}+i\sin\frac{\pi}{4}\right)$ *and* $z_2=\frac{1}{2}\left(\cos\frac{\pi}{6}+i\sin\frac{\pi}{6}\right)$;

№13. Find private: $z_1 = \sqrt{2}\left(\cos\frac{\pi}{8} + i\sin\frac{\pi}{8}\right)$ *and* $z_2 = 2\left(\cos\frac{\pi}{12} + i\sin\frac{\pi}{12}\right)$;

№14. Exponentiate: $\left(3\cdot\left(\cos\frac{\pi}{15} + i\sin\frac{\pi}{15}\right)\right)^5$;

№15. Extract square root from complex number: $25\left(\cos\frac{\pi}{3} + i\sin\frac{\pi}{3}\right)$;

№16. Write in algebraic form: $z = \left(\frac{1-\sqrt{3}i}{3i}\right)^2$;

№17.Find private:$5(\cos 100^o + i\sin 100^o)$: $\left(\frac{\sqrt{3}}{2} + \frac{1}{2}i\right)$;

№18. Exponentiate:$\left(\frac{1}{\sqrt{3}} + \frac{1}{\sqrt{3}}i\right)^{10}$;

№19. Extract square root from complex number:$\sqrt{-27i}$;

№20. Extract cubic root from complex number: $\sqrt[3]{1+i}$;

№21. Extract the fourth root of the complex number: $\sqrt[4]{16}$.

The results of the written work are shown in table 1. Here, the first line contains the numbers of the tasks, in the next lines the students graduated from the academic lyceum (AL), school (S), and professional college (PC). And also in separate lines shows the results of students who completed their studies in 2019. The number of students is indicated in parentheses.

№	1	2	3	4	5	6	7	8	9	10
AL (20) %	70	50	75	80	85	60	50	45	50	5,0
S (26) %	73,1	53,9	92,3	92,3	84,6	65,4	57,7	46,2	61,5	7,7
PC (43) %	72,1	46,5	93	95,4	81,4	62,8	48,8	48,8	37,2	7
2019(S 26) %	73,1	53,9	92,3	92,3	84,6	65,4	57,7	46,2	61,5	7,7
2019(PC27)%	66,7	55,6	92,6	92,6	77,8	59,3	51,9	48,2	33,3	3,7
2019(AL19) %	68,4	52,6	73,7	79	84,2	63,2	52,6	47,4	52,6	5,3
2019 (72) %	69,4	54,2	87,5	88,9	81,9	62,5	54,2	47,2	48,6	5,6
total (89) %	71,9	89	91	91	83	62,9	51,7	47,2	47,2	6,7

Continuation

№	11	12	13	14	15	16	17	18	19	20	21
AL (20) %	25	25	40	40	5,0	15,0	10,0	5,0	5,0	0,0	0,0
III (26) %	26,9	38,5	34,6	42,3	15,4	34,6	3,9	34,6	7,7	3,9	0,0
PC (43) %	9,3	27,9	25,6	27,9	9,3	23,3	0,0	7	4,7	7	0,0
2019(S26) %	26,9	38,5	34,6	42,3	15,4	34,6	3,9	34,6	7,7	3,9	0,0
2019(PC27) %	7,4	25,9	22,2	25,9	7,4	29,6	0,0	7,4	7,4	3,7	0,0
2019(AL19) %	26,3	26,3	42,1	42,1	5,4	10,5	10,5	5,3	5,3	0,0	0
2019(72) %	19,4	30,6	31,9	36,1	9,7	26,4	4,2	16,7	6,9	2,8	0
total(89) %	18	30,3	31,5	35	10,1	25	3	14,6	5,6	4,5	0

From the results obtained, it was found that most students correctly solved the 3rd, 4th, 5th examples. And more than 50% of students decided correctly examples 1, 2, 6, 7. But most of the remaining examples were not properly considered by students. These examples are the geometric representation of a complex number, trigonometric form, the execution of actions on complex numbers in trigonometric form.

It should also be noted that the results are practically independent of whether the students graduated from school or an academic lyceum.

To study the disciplines of algebra and number theory, analytic functions, it is important that they know the geometric interpretation of a complex number, the trigonometric, exponential forms of a complex number, the implementation of actions on them and their application.

The analysis of programs, educational literature [1,3,12] shows that the majority of educational elements on a subject are repeated. But, as we indicated above, there is no identical repetition, the context of learning is different. In the theory of algebra and number theory, the properties of the set of complex numbers are studied, and the level of abstraction increases. The number of concepts associated with complex numbers is increasing, complex numbers are considered as a numerical system. The same can be observed during the analysis of topics devoted to complex numbers of the course of mathematical analysis.

Based on the analysis of the results of the experiment and the analysis of textbooks, teaching aids dedicated to the study of complex numbers, we proposed the following levels of learning) and stages of abstraction that characterize the language of presentation ofαelements (educational information (table 1).

TABLE 1 LEVELS OF LEARNING ELEMENTS AND THE LEVEL OF ABSTRACTION OF THE PRESENTATION OF THE THEME COMPLEX NUMBERS

table 1

№	Educational elements	Secondary school				Bachelor (direction methodology of teaching mathematics)			
		α_b	α_f	β_b	β_f	α_b	α_f	β_b	β_f
1	Complex number in algebraic form	0	1	0	1	1	3	1	4
2	Equal Complex numbers	0	2	0	1	2	3	1	4
3	Onjugate complex numbers	0	2	0	1	2	3	1	4
4	Complex numbers operations	0	1	0	1	1	3	1	4
5	Opposite complex numbers	0	2	0	1	2	3	1	4
6	Mutually inverse complex numbers	0	2	0	1	2	3	1	4
7	Image of complex numbers on a plane	0	1	0	1	1	3	1	4
8	Real axis, imaginary axis	0	1	0	1	1	3	1	3
9	Complex number images as a vector	0	1	0	1	1	2	1	3
10	Rule parallelogram of addition of complex numbers	0	1	0	1	1	2	1	3
11	Trigonometric complex number form	0	1	0	1	1	2	1	3
12	Complex numbers in exponential form	0	1	0	1	1	2	1	2
13	Complex number module	0	1	0	1	1	2	1	4
14	Complex number argument	0	1	0	1	1	2	1	2
15	Transition from trigonometric to algebraic form	0	1	0	1	1	3	1	2
16	Multiplication and division of complex numbers given in trigonometric form	0	1	0	1	1	3	1	3
17	Moor formula	0	1	0	1	1	3	1	3
18	The square roots of complex numbers	0	1	0	1	1	3	1	3

The results of the study, in particular this table, were discussed at a seminar of the department "Mathematics" and were approved by teachers of the disciplines "Mathematical analysis", "Algebra and number theory".

These results can be used by school teachers to develop knowledge and competence of students on the topic of complex numbers, as well as mathematics teachers in higher educational institutions when choosing a method of teaching topics of complex numbers.

CONCLUSION

In the study of complex numbers in a pedagogical university, it is also necessary to establish continuity between the courses "Mathematical Analysis" (theory of analytic functions) and "Algebra and Number Theory". It is important to familiarize students (future teachers of mathematics) with the applications of complex numbers for solving problems of trigonometry, planimetry in circle classes or in disciplines of choice, when writing term papers, graduate works. In addition, in the course of geometry, students can recommend a comprehensive interpretation of Lobachevsky geometry, in the course of mathematical analysis, to study in detail linear-fractional functions in conjunction with mappings on the plane. As a result, students enrich their knowledge and skills on the topic "Complex numbers", students get the opportunity in the future to organize extracurricular activities of school students on this topic.

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