UNIVERSITY OF NOVI SAD
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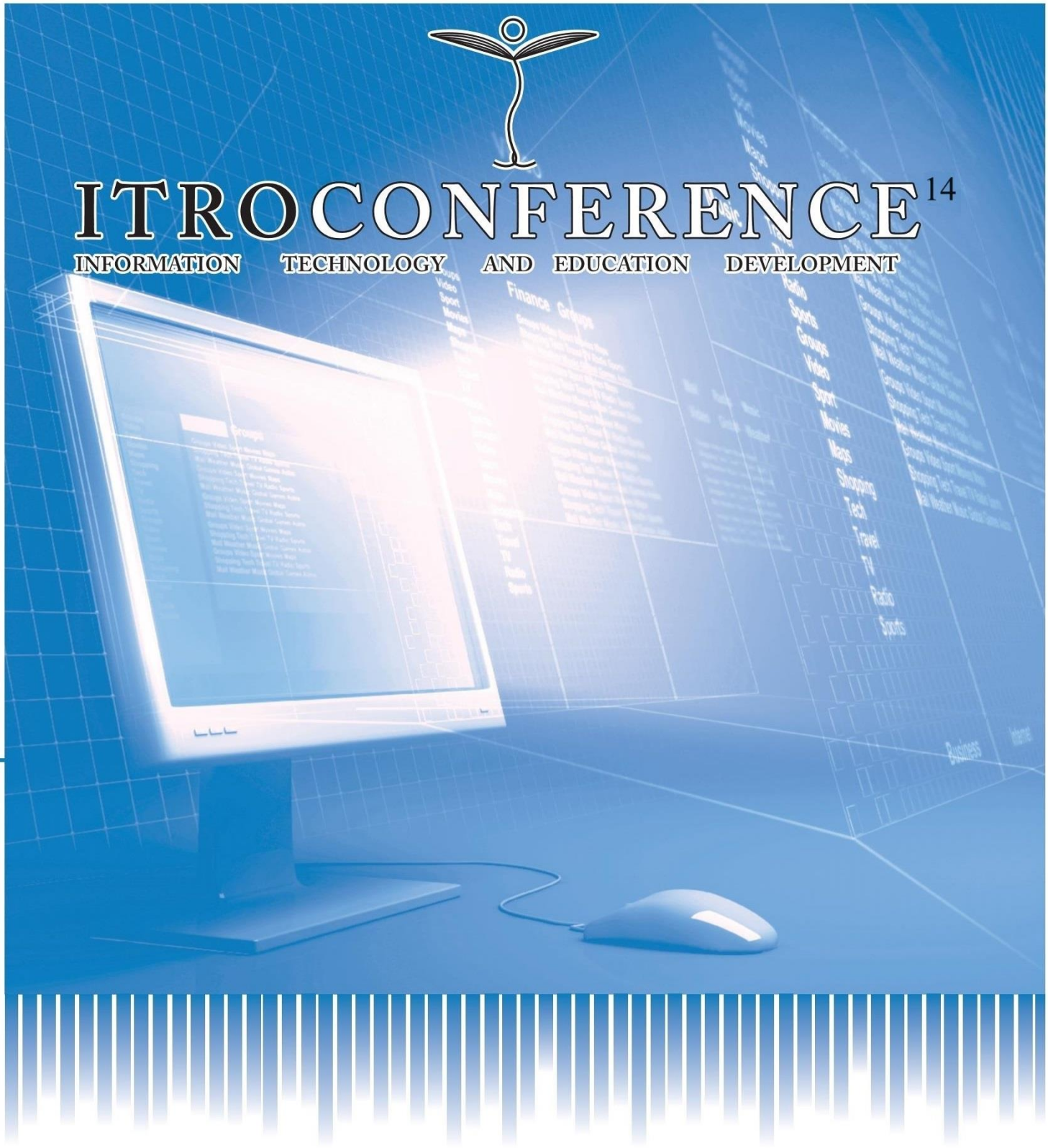
INFORMATION TECHNOLOGY AND EDUCATION DEVELOPMENT



PROCEEDINGS

ZRENJANIN, November 2023

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TECHNICAL FACULTY "MIHAJLO PUPIN"
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INTRODUCTION

International Conference on Information Technology and Education Development (ITRO) 2023, was held at the Technical Faculty "Mihajlo Pupin" for the fourteenth time. This year we have gathered our dear colleagues, scientists, researchers and students from several countries (Slovak Republic, Hungary, Macedonia, Bosnia and Herzegovina, India, Malaysia, USA and Serbia). They presented papers and promoted the results of research and scientific work in the field of information technology in education. The main course of the Conference was set up with some of the introductory lectures:

- "Challenges of the Technical Science Subject Teaching " held by Tünde Anna Kovács from Óbuda University, Bánki Donát Mechanical and Safety Engineering, Hungary;
- "VR Technologies in the Educational Process of Disabled People and in University Education On-line presentation" held by Csaba Szabó from Department of Computers and Informatics, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Slovak Republic. Author and co-authors: Branislav Sobota, Štefan Korečko, Miriama Mattová, and Gabriel Stromp;
- "Analysis of Students' Academic Achievements in the Field of Mathematics and Computer Science" held by Gordana Jauševac from University of East Sarajevo/Faculty of Transport and Traffic Engineering, Doboj, Bosnia and Herzegovina. Author and co-authors: G. Jotanovic, G. Jausevac , D. Nedic, D. Mandic (from University of Belgrade/Faculty of Education), and D. Glusac (from University of Novi Sad/Technical faculty "Mihajlo Pupin", Zrenjanin);
- "Toward intelligent data analysis in higher education institutions" held by Nina Bijedić from Faculty of Information Technologies University Džemal Bijedić of Mostar, Mostar, Bosnia and Herzegovina. Author and co-authors: A. Joldić and D. Gašpar.

The other presented papers have cast light on various aspects of contemporary education in our country and abroad, such as: school without mobile phones, the phenomen of academic boredom, augmented reality learning environment, cloud technologies in education, etc. They addressed experiences, problems, questions, etc. in relation with information technologies and education development.

The conference was financially supported by the Provincial Secretariat for Higher Education and Scientific Research, Novi Sad. The Technical Faculty “Mihajlo Pupin” has provided the necessary technical support.

The ITRO Organizing Committee would like to thank to the authors of articles, reviewers and participants in the Conference who have contributed to its tradition and successful realization.

See you at the next ITRO Conference,

Chairman of the Organizing Committee
PhD Vesna Makitan

CONTENTS

INVITED LECTURE

SCIENTIFIC PAPERS

Statistical Analysis of Knowledge for Topic Complex Numbers of Students From the First Academic Year

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Abstract - Students who decide to study at a technical faculty must be well prepared for all mathematical topics. Many of the students, at the beginning of their studies when they encounter math problems with complex numbers, face difficulties in solving them, even though they have already studied complex numbers in high school. In this paper an analysis of the knowledge of the topic complex numbers, of the newly enrolled students at the technical faculties at University Goce Delchev Shtip, is made. The need for such an analysis was realized a few years ago when it was observed how first year students had problems when complex numbers were mentioned. With an appropriate statistical analysis, we wanted to assess how well the students know how to solve problems with complex numbers, what they find most problematic when learning the subject of complex numbers and what difficulties they face. Based on the results of the analysis, we will offer a solution to overcome the problems that students face when solving problems with complex numbers.

I. INTRODUCTION

Every year at the technical faculties, it can be observed that enrolled students are with different knowledge about the topics they studied in the subject of mathematics. We concluded that every new year are coming students who, when complex numbers are mentioned, get confused, do not remember what they did in high school and encounter a problem when solving tasks. Complex numbers are a mathematical topic that students are introduced to for the first time in high school. This topic is quite abstract for students, because complex numbers are not the kind of numbers that students face in their daily life. Our experience with new students at the technical faculties at University Goce Delchev Shtip, led to the conclusion that students have a hard time learning the lessons of this topic. In order to change that, we got the idea to complement the classic approach to learning this topic with the mathematical software GeoGebra. The software is useful for visualization of the concept of a complex number, to find the module, power of a complex number, to present operations over the field of complex numbers, etc. GeoGebra is simple to use, free and supports solving problems with complex numbers. Software-assisted learning during mathematics teaching can be very useful in explanation of abstract terms. GeoGebra can be installed on a computer or can be used a web application. More about GeoGebra we can find in [1] and [2]. GeoGebra software is very popular in teaching mathematics [4]-[8]. The effect of use GeoGebra software in the achievement of students has been considered in [3]. About the importance of introducing new methods in learning, the importance of visualizing problems using software and the results of the same can be found in [9]-[12].

The main objective of this paper is to compare the knowledge that new students of technical faculties have about complex numbers before the beginning of their studies and after the lessons dedicated to this topic, during which the teaching is held with the application of software. We formed a group of students from the Technical Faculty of Goce Delchev University, with which we determined the knowledge of complex numbers through two tests, one before the beginning and one after the teaching on the subject of complex numbers in the beginning of academic year. In this paper we will present the results of the two tests and their statistical analysis. Finally, we will present the conclusions of this analysis.

II. MAIN RESULTS

Complex numbers are topic that students of technical faculties must know, which is why it is included in the subject Mathematics 1 in the first academic year. On the one hand, the importance of its application in most areas of technology and engineering, as well as other disciplines of mathematics, and on the other hand, the increasing tendency of difficulties in solving problems with

complex numbers from year to year, were the reason to make a statistical analysis. Because of that we decided, along with the standard materials, to include GeoGebra in the study of this topic. The educational software which we decided to use was GeoGebra, primarily because it is free and on the other hand it is easy to use.

First, after studying the topic of complex number in secondary school and before the new students start with the lessons at faculty, we did a test on a group of 19 voluntarily enrolled students to see if the results were satisfactory for the topic of complex numbers. Basic information about the students in the group is given in the following table.

TABLE I. PRELIMINARY INFORMATION ABOUT THE STUDENTS

Group structure		***Number of students***
Age	18-21	14
	other	5
Gender	F	11
	M	8
Total number of students in the group:		**19**

For assessing of the student's knowledge, we've designed a test consisted of 10 tasks. Below is given a sample of the test.

Test sample

1. Write down the opposite and conjugate complex number of $z_1 = 2+3i$. **/5 points**
2. For $z_1 = 2+i$, $z_2 = 3-2i$ find z_1+z_2, z_1-z_2, $z_1 z_2$ and $\frac{z_1}{z_2}$. **/10 points**
3. Calculate i^{-125}. **/10 points**
4. Find the power $(1-i)^{10}$ **/10 points**
5. Represent the complex number $\frac{3-4i}{7+3i}$ in algebraic form. **/10 points**
6. Write the complex numbers $z = -1-\sqrt{3}i$ in trigonometric form. **/10 points**
7. Find the modulus of the complex number $z = (-1+i)^4$. **/10 points**
8. Calculate $\left(\frac{1-i}{-1-i}\right)^{1087}$. **/15 points**
9. Simplify the expression $3\bar{z}-2z+1$ if $z = -\frac{1}{2}+i$. **/10 points**
10. Represent the following complex numbers in the complex plane: $z = 3+4i$, $z = -3+4i$, $z = -3-4i$, $z = 3-4i$. **/10 points**

Except the first one, which carries 5 points and the eighth, which carries 15 points, the other tasks are 10 points. Total number of points from all test tasks are 100. Students had 60 minutes to solve the test.

The results of the testing with which we wanted to assess the students' knowledge of the topic of complex numbers from secondary school are shown in the column "Points from first testing" of Table II.

Since the results were not the satisfactory, we decided, before starting with the intended content of the subject Mathematics 1, to hold extra classes in which we will solve tasks from topic complex numbers using the GeoGebra software. Additionally, we decided to restudy the topic with the application of ICT.

Fig. 1 trough Fig. 10 show how GeoGebra can be used for solving the tasks from the Test sample.

To get the solution of the first task in GeoGebra, we created complex number z_1 directly in Graphics, with the Complex Number Tool. Then we use the command *conjugate* (z_1) which we enter in Input bar to get z_2. Finally, we make a Check box with the Check Box tool for z_1 and z_2 (Fig. 1).

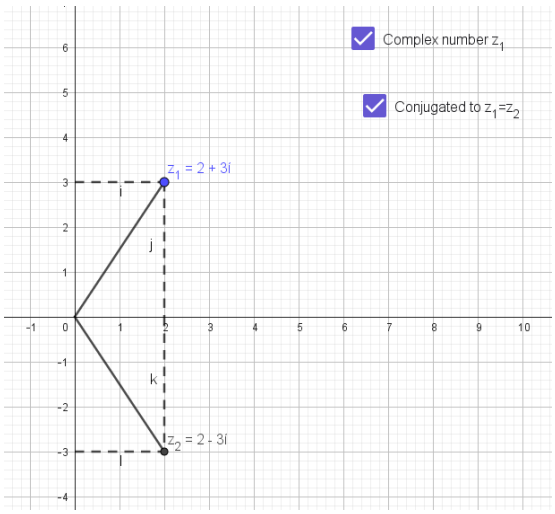

Figure 1. Solution of the Task no.1 with GeoGebra

For the second task we enter the complex number in Graphics and then in Input bar we enter $z_1 + z_2$, $z_1 - z_2$, $z_1 z_2$ and $\frac{z_1}{z_2}$. As a result we get the complex numbers z_3, z_4, z_5 and z_6 shown in Fig.2.

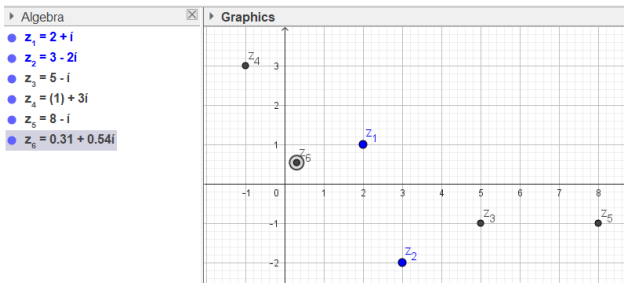

Figure 2. Solution of the Task no.2 with GeoGebra

For the third task we enter first the complex number z_1 and then in Input bar we enter z_1^{-125} and we get z_2. Check box for showing and hiding of z_2 is also made (Fig. 3).

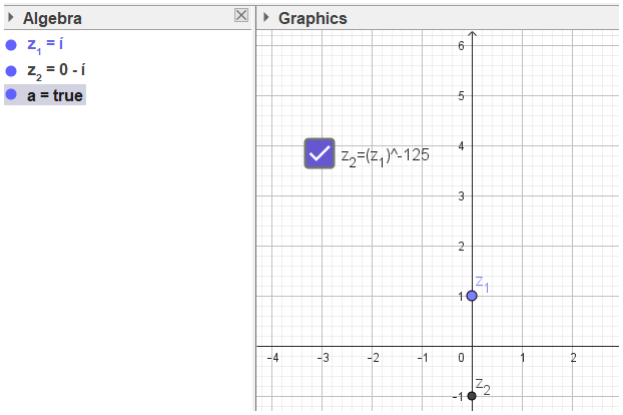

Figure 3. Solution of the Task no.3 with GeoGebra

For the fourth tasks we input complex number z_1 in the Graphics and then we got z_2 when in the Input bar we enter z_1^{10}. Check box for showing and hiding of z_2 is also made (as in Fig. 4).

In the fifth task, the complex numbers z_1, z_2 and z_4 are entered first in Graphics and then in the Input bar we enter z_1 z_2 and z_4 z_2 to get z_3 and z_5 respectively. In the end we enter z_3 / z_5 in the Input bar to get algebraic form of given number, z_6 (Fig. 5).

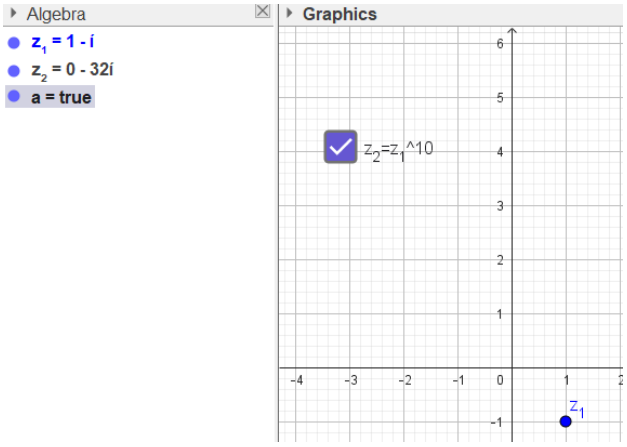

Figure 4. Solution of the Task no.4 with GeoGebra

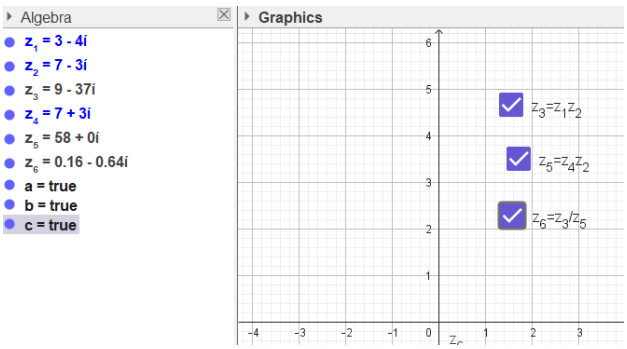

Figure 5. Solution of the Task no.5 with GeoGebra

In the sixth task we first find the modulus ρ. Then we find argument θ of z and we write the trigonometric form of z, by following the instruction are given in the static text in Graphics (as shown in Fig. 6).

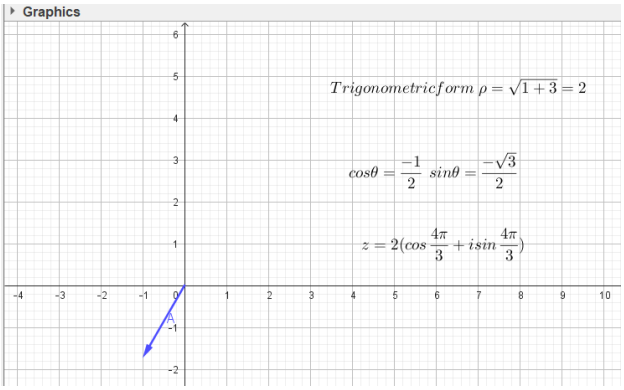

Figure 6. Solution of the Task no.6 with GeoGebra

In the next task 7 we enter complex number z_1 in Graphics and then we get z_2 after entering in Input

bar z_1^4. From z_2 it easy to get the modulus of z. (Fig. 7).

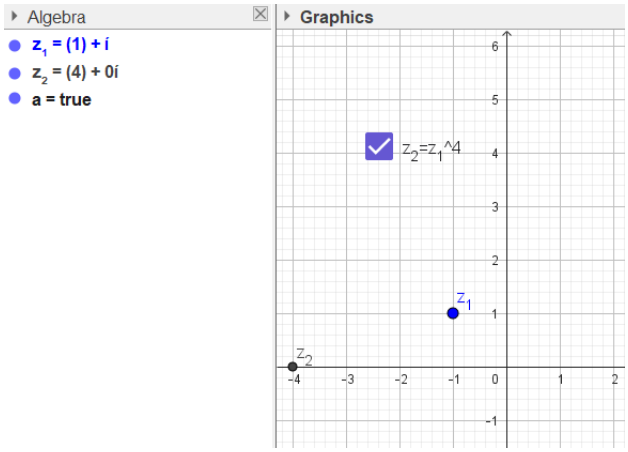

Figure 7. Solution of the Task no.7 with GeoGebra

For task 8 we enter the complex numbers z_1 and z_2 in Graphics. Then in Input bar we enter $(z_1 z_2)^{1087}$ to get z_3 which give us the solution of task (Fig.8).

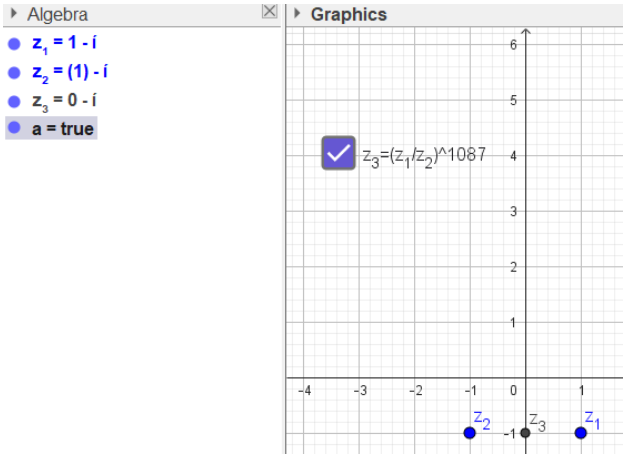

Figure 8. Solution of the Task no.8 with GeoGebra

In task 9 we enter the complex number z_1 in Graphics which is appropriate to z. Then we use the command *conjugate* (z_1) which we enter in Input bar to get the conjugate of z and we get z_2. In the end in the Input bar we enter $3z_2 - 2z_1 + 1$ and we get the solution of task (Fig. 9).

In task 10, the complex numbers z_1, z_2, z_3 and z_4 were created directly in Graphics, with the Complex Number Tool (Fig. 10).

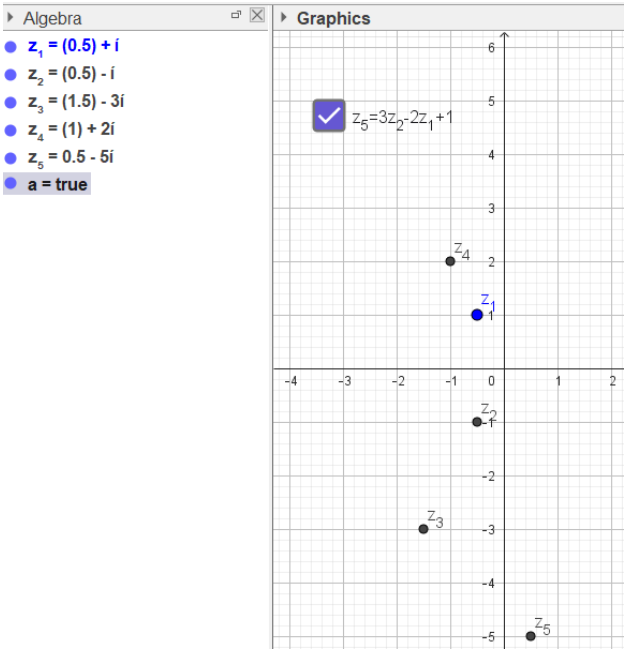

Figure 9. Solution of the Task no.9 with GeoGebra

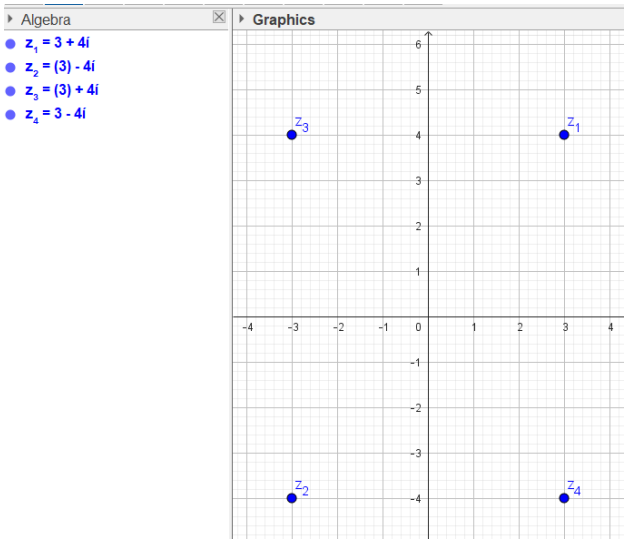

Figure 10. Solution of the Task no.10 with GeoGebra

After the classes in which tasks were solved with the help of Geogebra, as the examples listed above, we again conducted testing on the same group of 19 students. In the new test, the students had to solve the similar tasks as in the first test but now they had followed additional classes where they worked on tasks from the given topic using GeoGebra. When preparing for the new test at home, students could use the software to check the results they got when manually solving problems with complex numbers, and thus get motivation to work and solve a large number of problems. Solving time in the second test was also 60 minutes and the working conditions were the same as in the first test. Results of the second test with the same tasks with the first are

given in table 2 in the column "Points from second testing".

TABLE II. STUDENTS' ACHIEVMENTS ON TESTINGS

Student	*Student achievements*	
	Points from first testing	*Points from second testing*
1	100	100
2	71	96
3	79	92
4	100	100
5	55	90
6	65	68
7	89	100
8	65	75
9	91	93
10	100	100
11	38	59
12	65	65
13	34	41
14	30	33
15	62	78
16	70	92
17	43	51
18	100	100
19	27	44

From Table II it is obvious that the results after second testing is much better. It shows that the extra classes for the topic complex number in which tasks were solved with GeoGebra software helped the students to overcome the ambiguities and to improve knowledge about given topic.

To determine whether students' knowledge of the given topic can be improved if students are advised to use GeoGebra software when learning complex numbers, the following hypotheses were analyzed:

- **Null hypothesis**: There is no statistically significant difference between the achievements of students for the topic complex number in the beginning of their study in technical faculty so that they taught it in secondary education and the achievements of students after lessons for that topic in which are solved tasks with GeoGebra software in the beginning of study.
- **Alternative hypothesis**: There is a statistically significant difference between the achievements of students for the topic complex number in the beginning of their study in technical faculty so that they taught it in secondary education and the achievements of students after lessons for that topic in which are solved tasks with GeoGebra software in the beginning in study.

We performed a t-Test to test these hypotheses using the SPSS' Paired Samples T-Test for means comparison. The results are given in Table III.

TABLE III. PAIRED SAMPLES T-TEST

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	FirstTesting – SecondTesting	–10.15789	10.23210	2.34741	–15.08961	–5.22618	– 4.327	18	<0.01

Since the significance level Sig. (2-tailed) is less than 0.05, we have to reject the null hypothesis and we can say that there is statistically significant difference between achievements of students before and after the lessons in faculty in which the examples were solved with software.

Considering the results of both testing we can conclude that the extra lessons are very important and that it is good to advise students in learning the topic of complex number with the use GeoGebra. The t-Test shows that there was significant difference in the results of the students in the two testing before and after the lessons in faculty in which the examples were solved with software.

III. DISCUSION

Our research and its results gave valuable insights about the impact of the use of GeoGebra on the students' success and confirmed our opinion that

the impact will be positive. However, as any other similar research, it has certain limitations which should be acknowleged .

The study was conducted with a relatively small group of voluntarily registered students which may impact the generalizability of the findings to a broader student population. A larger group could provide a more comprehensive understanding of the effects of the use of GeoGebra on the students' success.

The participants in the study were from one academic year and one university. In order to obtain more relevant analysis, the study should be extended over a longer period, with students from other universities with similar syllabi. Proper control groups, a more diverse resources, alternative ways of implementation of GeoGebra into the teaching methods and different types of tests for the measurement of the student success, should also be utilized in the future studies of the impact.

IV. CONCLUSION

From Table II and Table III we can see that the application of ICT in the teaching of complex number is very important. The results confirm the general opinion that it is very important for students to have help in learning (in this case from the software). This is the only way they will get a greater desire to work, a greater interest in solving problems and thus achieve better results. The more thorough the students' knowledge is, the greater are the chances that they will apply it in practice successfully. Our research has also shown that it is good to use GeoGebra to improve knowledge and results on topic of complex number, and the t-Test showed that there was significant difference in students results in the two testings. The benefits and advantages of GeoGebra are enormous. Critical thinking, understanding and interest are much greater when working with this software compared to not using it, more knowledge is gained, tasks are solved more quickly and easily and excellent exam results are achieved.

With the help of GeoGebra, more students were motivated to study mathematics. The inclusion of GeoGebra, or any similar educational software in the teaching process brings many benefits such as facilitating learning, easier mastering of the material and achieving better results. Therefore, it is important to highlight the advantages of the use of educational software and its capacity to enrich the traditional teaching.

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