



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

Elena Karamazova Gelova

Sonja Mančevska

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Introduction

- At the technical faculties 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.

Introduction

- 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.
- 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 and one after the teaching on the subject of complex numbers with software in the beginning of academic year. In this paper we will present the results of the two tests and their statistical analysis.

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.
- 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.

Main results

- 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.

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

Main results

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

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

Main results

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

Main results

- 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.

Main results

- So, we explained to the students how to solve the tasks similar to the tasks from first test with the help of the software GeoGebra, indicating all the steps that will be done in GeoGebra.
- After the classes in which tasks were solved with the help of GeoGebra, 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 II in the column “Points from second testing”.

Main results

Table II.

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

Main results

- From Table II it is obvious that the results after second testing is much better.
- 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.

Main results

- **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.

Main results

Table III.

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
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.

DISCUSSION

- 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.
- 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.

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.

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