The Ubiquity of Mathematics in the Practical Basics of Computing and Programming

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***Abstract* - Most students of secondary technical schools find it difficult to learn the material from subjects that require logical and abstract thinking. Such students often resist and struggle to master material that requires this type of thinking, such as, for example, geometry. When acquiring content from programming subjects, for such students, abstract and logical thinking does not represent such an obstacle in solving tasks as is the case with mathematics. In practical subjects, such as the practical basics of computing, the correlation with mathematics did not give them problems. The research was conducted using a questionnaire containing 15 open and closed questions. The respondents are students of a high school that educates students in electrical engineering and computer science.**

The goal of the research was to investigate the cause of such students' approach to mathematical tasks and to find out which teaching methods and teaching aids would help students in presenting abstract tasks. The conclusion is that students are more motivated when solving tasks by writing computer programs because running the written code makes it easier for them to make logical connections and abstract thinking. Proposals for teaching methods and teaching aids for teaching mathematics were also made to facilitate students' acquisition of teaching content.

Keywords - mathematics, programming, teaching topics, students, algorithm

I. Introduction

The article describes the research on the causes of the difficult acquisition of mathematical material where logical and abstract thinking is required, as well as the application of different teaching methods and aids for presenting tasks. The research was carried out in a high school where students are educated in various technical professions.

We paid the greatest attention to Computer Technicians.

With the new professional curriculum in 2017 for obtaining the qualification of Computer Technician in the educational sector of Electrical Engineering and Computing, Workshop exercises were abolished and programming courses were added. It was noticed that after that year there are minor problems with the acquisition of mathematical topics. Students often complained in math classes about abstract concepts like vectors. In the lessons on algorithms and programming, students could see the application of vectors such as movement coordinates in an example of coding a computer game. After several such examples, the students noticed that their mathematical knowledge is the basis for other subjects at school.

After mutual communication between experts in mathematics and programming, it was decided to implement new teaching methods and aids when presenting and solving mathematical problems in mathematics. At the same time, students in the second grade solved mathematical topics on algorithms and mathematics during the same period.

The results were achieved with the positive motivation of the students and the desire to understand mathematical topics that are useful to them in programming.

We followed the students for five months while teaching the topics of quadratic equations, quadratic inequality, and quadratic function in the second grade of Computer Technician at the School of Electrical Engineering in Zagreb.

When acquiring new knowledge from the topic of quadratic equations, quadratic inequalities, and then quadratic functions, students have behind them nine years of school mathematics, acquired knowledge and skills that need to be upgraded in such a way that the students themselves are motivated for knowledge and have the will to work.

For students to learn the material more easily, according to Mayer, the following principles should be followed. The dual-channel hypothesis holds that learners can divide information into two distinct cognitive structures, the visual channel, and the aural channel. The second supposition is that one channel's capacity for processing information is constrained. To avoid a cognitive overload, it is advantageous for learning settings to promote the engagement of both the visual and auditory channels. This can be accomplished, for instance, by combining spoken texts or spoken images with written texts or visual visuals. The third supposition holds that to absorb new information, students must actively interact with the learning material [1],

Before starting the research, the students learned how to solve quadratic equations in mathematics class. General equation solving is the basis of solving all problems, so the goal is for students to apply equation solving to real-life problems. The problem tasks are reduced to the text of solving life problems, however, the biggest problem was reduced not to set but to solving equations. They independently created algorithms for solving quadratic equations.

The research included second-grade students of the Electrical Engineering School in Zagreb.

Participation in the research was anonymous and voluntary, conducted through a Google Forms survey. Students were asked 15 survey questions, 5 open-ended and 10 closed-ended.

On three closed-ended questions, students could justify their answers. The answers to the questions indicate their own choices that the students had at the time of filling out the survey. 45 students participated in the survey.

In response to the first question, which read "Knowledge of programming helps me to learn the teaching contents of mathematics: " the respondents had to indicate their level of agreement with this statement. The answer can be seen in Figure 1.

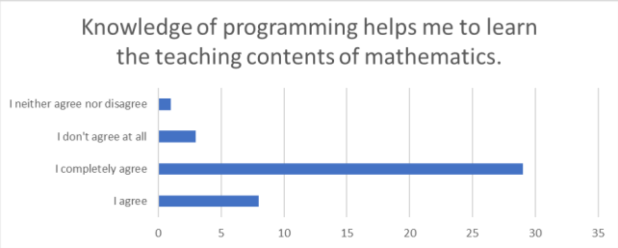

Figure 1. Knowledge of programming helps me to learn the teaching contents of mathematics

The next question, also of closed type, related to the visualization of mathematical problems, read: "Visualizing mathematical problems helps me to solve tasks." The answers offered were "Yes" and "No".

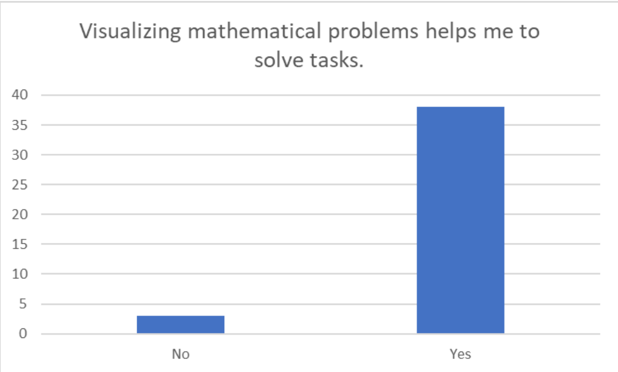

Figure 2. Visualizing mathematical problems helps me to solve tasks

Figure 2. shows that 38 respondents answered Yes while 3 answered No.

Then followed another closed question, "I often use online tools and applications to solve mathematical problems more easily." The ratio of "Yes" and "No" answers was almost equal, as can be seen in Figure 3.

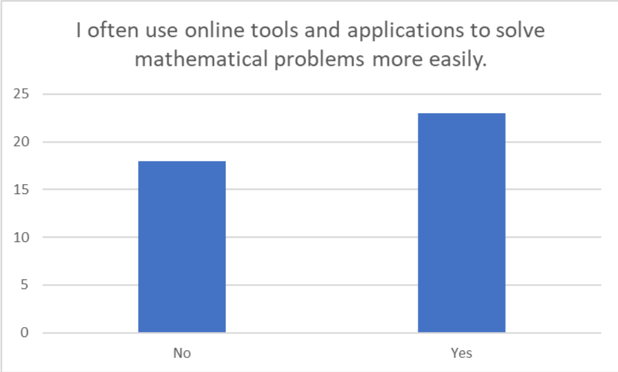

Figure 3. I often use online tools and applications to solve mathematical problems more easily

Figure 4. shows the ratio of respondents who often use online tools and applications when solving mathematical problems and those who do not.

The fourth question related to the method of solving the quadratic equation. The answers were offered: formulas, factorization, calculators, PhotoMath, Desmos, programs in C, I don't solve.

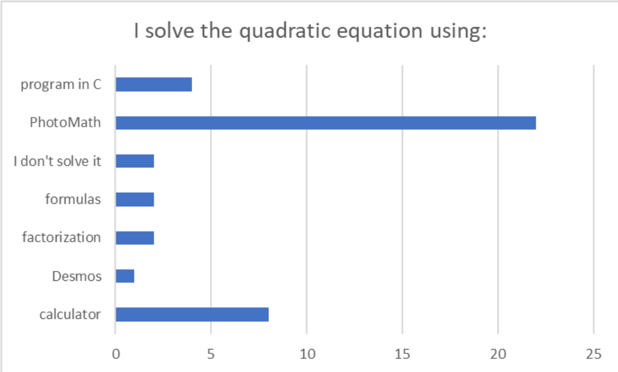

Figure 4. I solve the quadratic equation using...

Figure 5. The graph shows the percentage of respondents regarding the survey question: "I solve a quadratic equation using..."

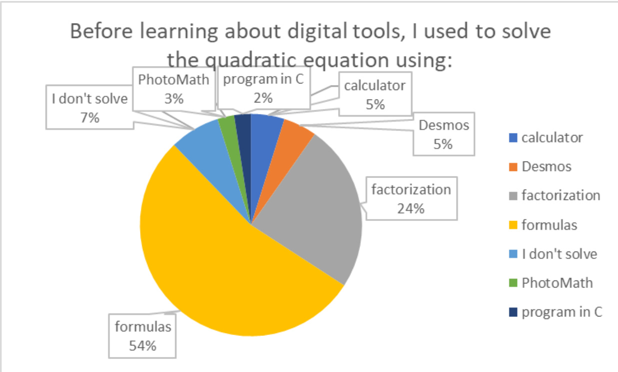

Figure 5. Before learning about digital tools, I used to solve the quadratic equation using…

II. Digital Environment

The digital environment consists of all ways of using computers and the Internet. These include, among others, smartphones, computer games, online tools for solving tasks, and social networks.

According to [2], the study of student problems takes place within natural science and computer, informatics subjects according to the approved curriculum of the Ministry of Science and Education. During the research, the students were introduced to a smart calculator with which they can solve quadratic equations of any type[3]. The students were introduced to the PhotoMath application, which automatically displayed the procedure for solving and solving the given quadratic equation. Continuing with the mathematical topics of quadratic equations and quadratic inequalities, the quadratic function and its graph follow. Understanding a quadratic function, drawing it, and researching it takes time, so students are allowed to use a calculator, tablet, mobile phone, or computer to solve the quadratic equation as quickly as possible.

After the students were taught to use numerous online tools and applications to solve math problems, they were again asked the fourth Question. Unlike last time, the results turned towards digitalization, as we can see from Figure 2. Most of the students use a calculator, some use a mobile phone with PhotoMath, and a very small number stayed on the formula for the quadratic equation.

Figure 6. The graph shows the percentage of respondents regarding the survey question: "I solve a quadratic equation using..."

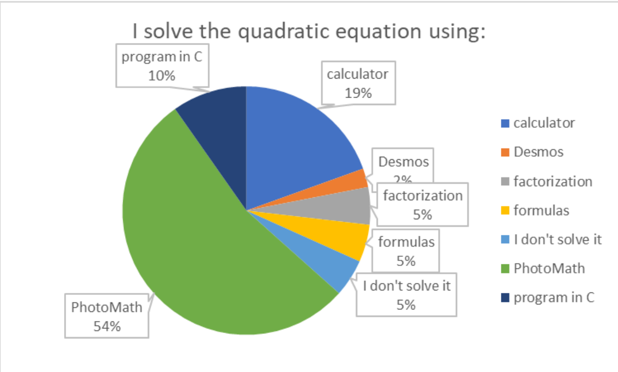

Figure 6. I solve the quadratic equation using...

We divided the students into teams when drawing graphs of quadratic functions and their research.

Students are divided into six teams:

team A with tasks and solutions on a piece of paper, team B with tasks using Geogebra, team C with tasks on a piece of paper and a calculator, team D with tasks on a piece of paper and mobile phones, team E without tasks - creative creation of tasks with a calculator, team F without tasks - creative creating tasks with a mobile phone. The eighth question is open-ended and related to working in teams, respondents had to fill in how many tasks they were able to solve together (as a team) during one hour, considering which team they belonged to.

It turned out that most tasks were solved in teams that independently created tasks and solved them. Students were surveyed after working in teams.

Teams that solved tasks using PhotoMath, calculators, or Geogebra solved more tasks than students who did not use technology, while students without digital tools had the lowest number of solved tasks.

Figure 7 shows the number of solved tasks by teams.

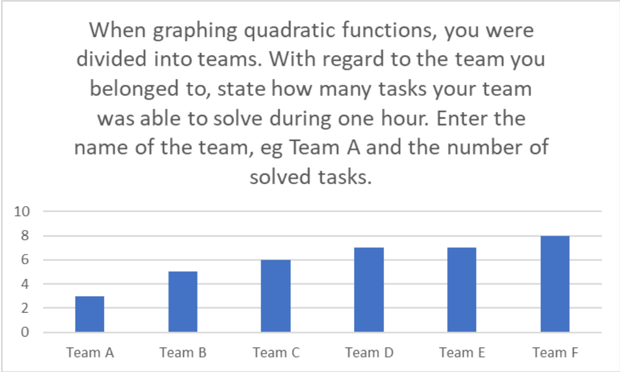

Figure 7. Tasks solved by teams

A Kahoot quiz was used to check the understanding of mathematical topics. As the survey showed, the quiz within the class also showed that students who use a calculator or mobile phone find solutions more easily and understand the teaching topics better. According to [4], the motivation to use digital technologies is increased because we all live in the digital age and behave that way.

The ninth and tenth questions refer to the application of programming in C as a motivation for solving mathematical problems.

Thanks to the excellent cooperation and communication of science teachers and vocational teachers, at the same time, students in the Algorithms and Programming course used the discriminant of a quadratic equation, which they had difficulty connecting with the quadratic function in mathematics. [5] In the course Algorithms and Programming, students learned the concept of function in programming. Their task was to write a function called Discriminant, which receives as arguments the coefficients of the quadratic equation (a, b, and c) and calculates the discriminant according to the entered parameters. After that, the program should have printed a message about how many solutions the quadratic equation with such parameters has. By running the program multiple times and entering different parameters a, b, and c, the response of the program was different depending on the calculated discriminant. Using the example of that task, the students understood the application of the quadratic function.

In the article, research was conducted on the use of digital technologies, teaching methods, and means for improving the understanding of teaching topics in mathematics.

The eleventh and twelfth questions refer to the use of teaching methods in teaching mathematics. The eleventh question read: "In mathematics classes, my favorite teaching method is:", and the answers offered were individual work, work in pairs, teamwork, or work in groups.

The respondents prefer teamwork, which is evident from the graph in Figure 8.

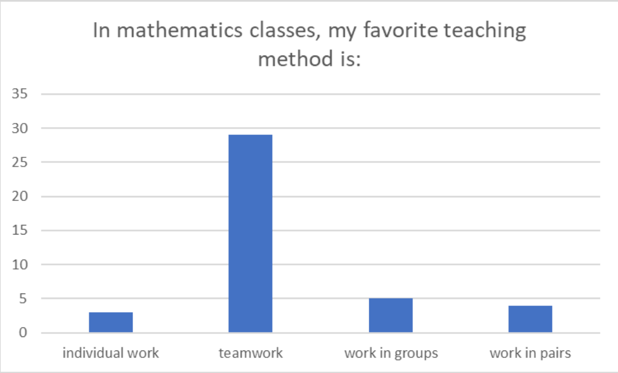

Figure 8. Favorite learning methods

The thirteenth question was open-ended and read: "Which digital tool for solving mathematics problems do you use most often?"

Respondents most often use PhotoMath, while they use Desmos a little less, which is visible from the graph in Figure 9.

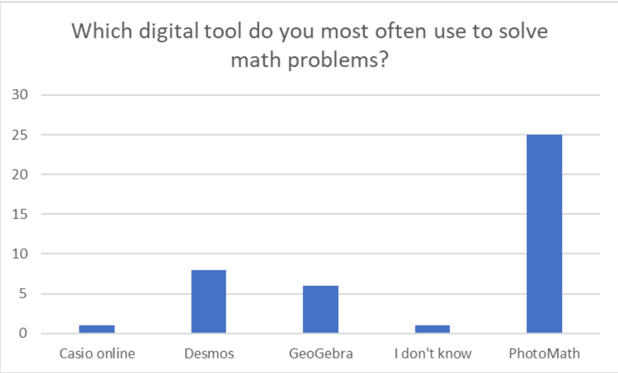

Figure 9. Digital tools

The fourteenth and fifteenth questions were related to the assignment of project tasks in mathematics classes. It was concluded that students prefer project tasks in mathematics because they stimulate the spirit of inquiry, are interesting, and always learn something new from them.

III. Research Evaluation

The research included second-grade students of the Electrical Engineering School in Zagreb this article aims to show an example of good practice and to encourage other teachers to work on cross-curricular topics because they make it easier for students to learn teaching content.

.Participation in the research was anonymous and voluntary, conducted through a Google Forms survey. Students were asked 15 survey questions, 5 open-ended and 10 closed-ended.

On three closed-ended questions, students could justify their answers. The answers to the questions indicate their own choices that the students had at the time of filling out the survey. 45 students participated in the survey.

In general, although it is not required, prior arithmetic knowledge might be helpful when studying programming. Logic, abstract thought, problem-solving, and an understanding of mathematical concepts like algebra and geometry—which are also utilized in programming—are just a few of the abilities and knowledge that learning mathematics can provide you.

To learn to program, you do not need to have any prior arithmetic expertise, though. Since programming is a distinct ability, it may be learned and understood without prior mathematical understanding. Students can learn programming using a variety of techniques, such as visual-based tools, and block programming, or by starting with simple languages with fewer mathematical prerequisites, like Python or Scratch.

On the other hand, programming, and mathematics frequently support one another. Students can use programming to apply mathematical ideas to real-world issues like computation, data analysis, statistics, or simulations. Additionally, mathematics can be helpful in more complex programming disciplines like algorithms, cryptography, machine learning, and video game development.

The ease or difficulty of learning programming ultimately depends on a variety of variables, including the student's particular aptitude, learning preferences, hobbies, and motivation. Although it can be helpful, prior mathematical knowledge is not required to learn to program.

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