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Research Article

EDUCATIONAL SOFTWARE AS RESOURCES FOR IMPROVING MATHEMATICS TEACHING IN PRIMARY SCHOOLS

[1,*]Ajla Halilović, [2]Sanela Nesimović and [3]Safet Velić

[1]Pre-University Education Institute, Sarajevo Canton, Aleja Bosne Srebrene bb, 71000 Sarajevo, Bosnia and Herzegovina
[2, 3]University of Sarajevo – Faculty of Educational Sciences, Skenderija 72, 71000 Sarajevo, Bosnia and Herzegovina

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Abstract

The introduction of modern technologies into the teaching process has led to significant changes in the entire education system. Innovation in teaching is one of the key tasks of the educational system, which leads to the improvement of the teaching process. The goal is to make teaching interesting and creative, following the needs and abilities of students. Today's education system focuses on students. The teacher is the bearer of new tasks and challenges as a researcher with a creative approach using information and communication technologies (ICT). The introduction of educational programs as a resource in the teaching process leads to an increase in society's interest in scientific and technical literacy, in the wide application of scientific achievements, and in training those who will further develop and improve these achievements. The use of educational programs for the preparation and delivery of mathematics lessons contributes to bringing students closer to certain concepts, teaching units, and areas in a clearer way, increasing their curiosity and desire for further learning and research. Today, there are various interactive programs for developing students' logic that help them to understand various contents more easily and more fully, especially mathematical ones. Some programs have proven to be very effective in working with children with developmental disabilities. As part of this paper, research was conducted on the attitudes and opinions of Mathematics and/or IT teachers regarding the application of educational software for the preparation and delivery of mathematics lessons. Based on the obtained results, it was determined whether teachers are ready to innovate their work by applying educational software. that is, whether they are ready for the reform processes that are current in our country. The subject of the research is a socially current topic in the daily development of ICT and represents one of the important trends today.

Keywords: Educational software, Mathematics, Information and Communication Technologies (ICT), Primary schools, Teaching improvement.

INTRODUCTION

Information and communication technologies (abbreviated ICT) are changing quite quickly and various hardware and software equipment (hereinafter referred to as computer equipment) are introduced in all areas of study. Therefore continuous training and support in work is necessary for the development of digital competencies of teachers. The teacher can use his knowledge and practice to encourage students to acquire digital skills (Eurydice, 2012). In the same way, with teacher's lack of interest or insufficient knowledge, can be the cause of the negative attitude of the students. It is becoming increasingly common that students are more computer literate than teachers due to the frequent use of technology for entertainment purposes. However, the teacher's role is to redirect that knowledge for educational purposes. To be able to do this, they must follow the generational trend, and keep up with it because what was current twenty years ago is now very likely considered outdated and not at all interesting to students. That is why constant self-education of teachers is very important (British Council, 2017). Developed digital competencies among teachers arouse greater interest in students and open opportunities for applying mathematical knowledge in various professions in the future such as programmers, economists, accountants, engineers of technical sciences, and the like. The introduction of modern ICT for the improvement of teaching and the use of educational programs in the teaching of mathematics will bring students closer to certain concepts, teaching units, and teaching areas, thereby increasing the level of comprehensibility and interest (Ferrari, 2012). Mathematics education programs are designed for innovative, interactive, and dynamic learning in different areas of mathematics. Innovation in teaching is a key task and need of the educational system because the goal is to make teaching interesting and creative by following the needs and abilities of students (Stojkić *et al.,* 2015).

Corresponding Author:** ***Ajla Halilović,
Pre-University Education Institute, Sarajevo Canton, Aleja Bosne Srebrene bb, 71000 Sarajevo, Bosnia and Herzegovina.

Theoretical framework

The use of digital technologies in the teaching process is necessary. Students should be trained to follow modern technological achievements. That is why continuous improvement of learning methods and means through monitoring and evaluation of the teaching process is necessary. Students today are constant users of technology. They can check the information they get from the teacher every day and give a critical opinion. The teacher's job is to adapt to the environment in which they grow up and accordingly organize classes. That is why teachers and students must have regular and unhindered access to technologies that support and improve education (especially mathematics), problem-solving solving, and communication. When teachers use technology strategically, they can provide better access to math knowledge for all students. Various educational software have been developed for many school subjects, and there are also adequate educational software for mathematics. As a teaching subject, Mathematics is a subject that is accompanied by various prejudices, which very often have no real basis. It is necessary to work on demolishing such prejudices because mathematics permeates every segment of our environment, and

therefore life in general. One of the ways to achieve this is through the application of educational software in various segments of the teaching process. Educational computer software can be used in all stages of the lesson, as well as in individual stages of teaching. In both cases, it is necessary: to prepare students, present new content, practice, repeat, and confirm. With this kind of teaching, interactivity increases and it goes beyond the traditional framework of teaching. The teacher is not only a lecturer and the only source of information, but his role is as a mentor who encourages the active participation of students in classes through the coordination of resources. Through this kind of teaching, students understand the teaching contents more easily, achieve better results, think critically, discover new concepts, and, most importantly, solve tasks in an easier way (Žuvić et al., 2016). According to Rogošić, Baranović, and Šabić (2021), teachers use ICT equipment for daily activities (to prepare and conduct lessons, to communicate with parents, students, and colleagues, and to monitor student achievements). They are aware that ICT improves the way students acquire knowledge, but they do not consider themselves sufficiently qualified for its application as a form of innovative teaching, and they cite technical deficiencies, lack of time, and low financial income as the reasons for this. According to Ranđelović and Veljović (2018), existing software development should offer several new specialized digital systems for student responses, the so-called CRS (Classroom Response Systems) application.

There are various math software. All of them, whether they require installation or are used in an online environment, can be used through various mathematical content. They enable the improvement of the performance of new material and facilitate practice, testing, and other activities. To improve the teaching process, teachers must familiarize themselves with the use and possibilities of educational software. Software suitable for use in teaching mathematics is divided into commercial and non-commercial software (Mathematica, MatLab, Maple, Easy Java Simulations, Wiris, Sage, GeoGebra,...).

Mathematica is a software package with great application possibilities: numerical data processing, symbolic processing capability, and a system for the graphical display of data and functions. This application marks the beginning of modern technical studies (Stanimirović, Milovanović, 2002). Application of the Mathematica software package requires certain programming skills. The closedness of the code represents great limitations in its use, and this is the reason why it is not widely used in elementary schools.

MatLab is a high-level programming language primarily intended for engineers, but today it is used in universities around the world. It is intended for numerical problem-solving and has 2D and 3D graphics. This program package is quite expensive, but it has some free programs such as Octava, Scilab, and FreeMat (Kostić, 2006). It offers enormous possibilities for working with symbolic variables (Kostić *et al.,* 2014). Due to its complexity, MatLab has not been widely used in primary schools.

Maple is a user program intended for advanced mathematical calculations, which include algebra, discrete mathematics, numerical and symbolic calculations, graphical display of results, etc. Similar to MatLab, Maple is an interpreter, ie. it executes commands one after the other and contains a large number of built-in functions and operations, grouped by appropriate areas (Abell, Braselton, 2005).

Easy Java Simulations (EJS) is a program for creating interactive simulations (applets). EJS is used to create sophisticated interactive simulations in local virtual laboratories, web laboratories, and laboratories with remote access (Popović, Naumović, 2013). It is necessary to have basic knowledge of programming, and creating simulations of physical and technical systems. It is used in engineering education. *Wiris* is a program for creating tests in mathematics and this program can be easily implemented in e-learning. So, concrete examples of the use of the Wiris program for assessment in mathematics classes are the creation of tests with multiple answers and other types of questions (Mašović, 2011). *Sage* (abbr. System for Algebra and Geometry Experimentation) was developed in the Python programming language. It is used for various areas of mathematics: algebra, numerical mathematics, combinatorics, number theory... It is easy to use and that is why it is used by beginners, and it can be used for advanced services. *Sage* is a network service, and one of the uses of that service is "cloud", where it has a web environment for short calculations, called *SageCell*, which is not characteristic of other mathematical programs (Ćosić, 2014).

GeoGebra is a free dynamic mathematics program that connects geometry, algebra, analysis, statistics, probability, 3D geometry, symbolic computation (CAS), spreadsheets, etc. There is also a free online version, ie. it is an open-source application. Apart from the teaching of mathematics, the use of *GeoGebra* is increasingly being introduced into the teaching of all STEM subjects. The program has been translated into more than 50 world languages. In many countries, *GeoGebra* is integrated into textbooks. Some of the advantages of using the *GeoGebra* program in teaching mathematics are free and simple installation, display of coordinate system, graphic display of functions, connection of graphic and analytical display, dynamics of objects, recording of works in different formats, and others. With free interactive material, it dynamically improves student knowledge and teacher competencies. The advantage of the application for students is in the process of visual mastery of mathematical material. It increases interactivity between teachers and students, all to improve the quality of teaching (Kostić, Gavrilović, 2011). Unlike the previously mentioned software, *GeoGebra* has found wide application in teaching mathematics. According to Maksimović *et al.* (2018), *GeoGebra* has a positive impact on students' motivation, enthusiasm, and self-confidence, and students believe that it should be an integral part of regular classes.

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Methodological framework

For this work, research was designed related to the attitudes and opinions of teachers on the application of educational software in teaching mathematics. The research problem is how to bring the teaching of mathematics closer to the students and to facilitate the understanding of mathematical areas by improving the delivery of teaching in primary schools. The teaching of mathematics should be made interesting and creative, following the needs and abilities of students, because knowledge of mathematics is necessary in all branches of natural and technical sciences. The subject of research is the application of educational software for the improvement of mathematics teaching in elementary schools. Improving the teaching of mathematics in primary schools, applying educational software as resources for learning and teaching, introducing new possibilities through the use of computers in teaching mathematics, and all to increase students' interest in functional comprehension, and understanding of mathematical content. Our educational system has long since shown that a comprehensive reform of the entire system is necessary and that the reforms so far have been carried out mostly only in certain segments, without quality analyses. The bearers of the reform are teachers. Without their enthusiasm and desire for change starting from themselves, no reform is possible. The goal of the research is to examine the opinions and attitudes of teachers about the application of educational software in mathematics teaching as a factor that affects the improvement of the quality of learning and the increase of student motivation (which directly affects the efficiency of knowledge acquisition). It is necessary to investigate the attitudes of teachers toward the application of educational software in the teaching of mathematics, which will prove or disprove the justification of the use of computers in the teaching of mathematics when processing or repeating certain teaching contents. The research has social significance because it points to a topic that is socially relevant in the daily development of ICT and represents today's trends. The social significance of this research is reflected in the fact that the participants of the teaching process are shown the use of ICT in teaching and the simple exchange of digital teaching materials, improving the teaching process. 149 Mathematics and/or IT teachers working in primary schools in Sarajevo Canton participated in the research. The research was conducted in the academic year 2022/2023. using a Google Forms survey questionnaire that was specially created for research within this paper. After obtaining the results of a survey of teachers and finding out how ready they are to use modern methods in teaching, they were offered teaching materials that can be downloaded from the website www.geogebra.org with instructions, applications, and concrete examples for teaching mathematics using free software GeoGebra. Some of the findings speak in favor of the fact that for the successful implementation of this type of teaching, the development of digital competencies of mathematics teachers and the equipment of the school in terms of appropriate computer resources are necessary. and the implementation of the lesson through the application of educational software largely depends on this. If a teacher successfully uses educational software, it is understood that his/her teaching will be better and of higher quality and that he/she will be able to motivate students and encourage them to work and achieve better results, and therefore to use educational software independently (Carretero, Vuorikari, Punie, 2017). Guided by the stated aim, object, and research problem, we have set several research tasks.

(Z1) Examine and determine whether teachers use educational software in their work.

(Z2) Examine and determine whether teachers are ready for new teaching methods based on the use of educational software.

Guided by these tasks, we set the main hypothesis of this research.

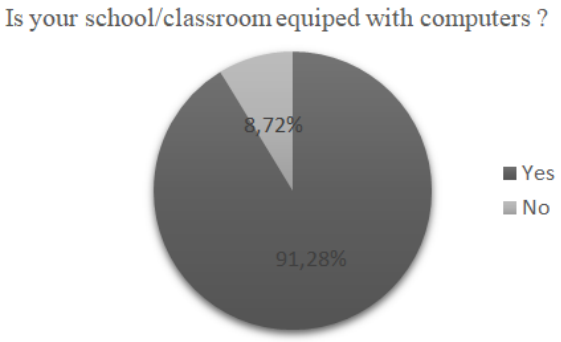
(GH) By introducing IT in their work as an innovative work method, teachers are ready to improve the teaching of mathematics, and thus the entire educational system.

Several sub-hypotheses emerged from the main hypothesis. (PH1) Teachers use educational software in their work.

(PH2) Teachers are ready for new teaching methods based on the use of educational software.

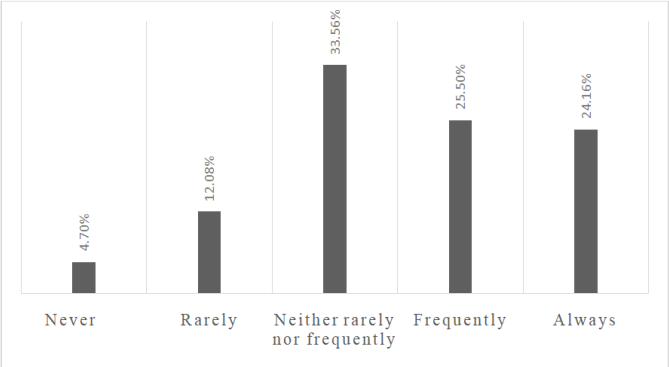
RESULTS

As part of our first research task to examine and determine whether teachers use educational software in their work, that is to check the first sub-hypothesis, we analyzed the answers of the surveyed teachers and presented them in the continuation of the work. For educational software to become an everyday part of our educational system, we must first examine how well schools are equipped with computer equipment. Any changes or innovations will not be possible if the schools/offices do not have the appropriate equipment. We asked the teachers to tell us what the situation was in their schools (Graph 1).



Graph 1. Teachers' answers about the computer equipment in their schools

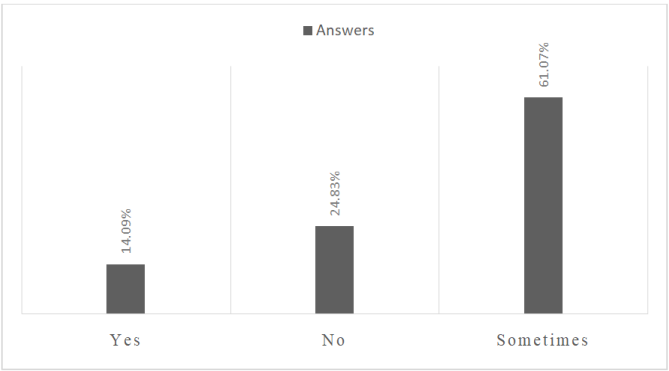
Therefore, more than 90% of schools are equipped with computer equipment, which is certainly a large percentage. However, in the times we currently live in, where it has become unthinkable not to have access to the Internet, we do not consider this percentage to be satisfactory. The next thing we investigated was to examine how often teachers use the computer in mathematics lessons and to express their attitude on a scale from 1 (I never use it.) to 5 (I always use it.) (Graph 2).



Graph 2. Teachers' views on the frequency of computer use in mathematics lessons

As shown, 16.78% of teachers rarely or never use computer equipment in mathematics classes, while 49.66% use it often or always. There are also 33.56% of teachers who believe that they use it neither rarely nor often. Considering the living conditions in which our students grow up and their interests, it is unacceptable that approximately 17% of teachers do not use computer equipment in their classes. Although this percentage does not seem large, it does not follow the degree of its presence in students' lives. This is not to say that the classic way of working in mathematics classes has become inadequate, but only that it needs to be adapted to the new generations and aligned with their interests. We also investigated whether teachers use educational software.

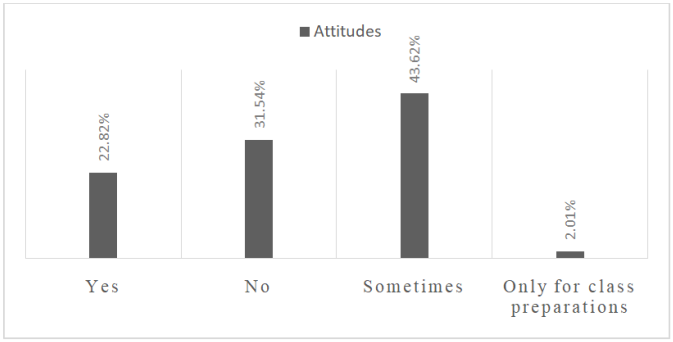
We presented their answers graphically (Graph 3).



Graph 3. Do teachers use educational software in their work?

So, 75.16% of teachers use educational software in their work. In contrast, nearly 25% of teachers do not use it, which is a fairly significant percentage as it represents a quarter of the respondents. Teachers have mentioned the following educational software they use and their purposes, or the subject areas within which they use them: GeoGebra (geometry, systems of linear equations, functions, for lesson preparation, to illustrate construction steps, mathematical games...), Desmos (graphing functions), Edmodo (organizing materials, posting and quizzes), Kahoot (quizzes), Potatoes (quiz, multimedia teaching), Google platform (student organization), Office, Scratch (mathematics in programming and demonstrating mathematical solutions visually), MS Excel (tables, functions, calculations), Algebrator, Word (Equation), MS Mathematics (printing formulas, fractions...)

The GeoGebra software proved to be simple and functional when it comes to the clarity of geometric content. We were particularly interested in how often teachers use it in the context of teaching mathematics (Graph 4).



Graph 4. Teachers' opinions on the frequency of using the educational software GeoGebra

According to the results we obtained, 66.44% of teachers use GeoGebra software to some extent. In contrast, the percentage of 31.54% of teachers who do not use it is quite significant, and there is a need for future efforts in this field. GeoGebra is a tool that is user-friendly, free, and also has an online version. It doesn't require extensive IT knowledge to master successfully. These are some of the reasons why additional teacher training in this case should be considered.

We also asked the teachers about their familiarity with GeoGebra and to list what they are familiar with and what they use within this software. They provided the following options (Table 1):

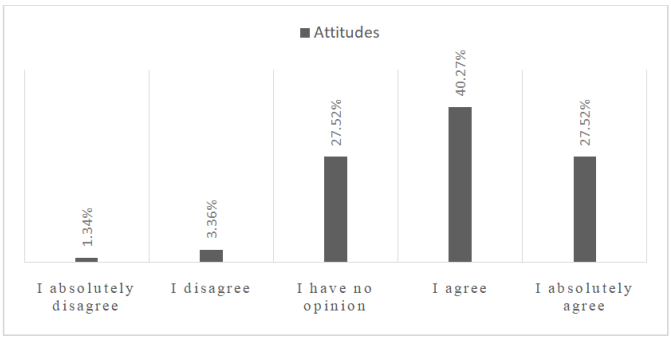
By analyzing the provided responses, we can conclude that teachers primarily use GeoGebra for similar content. It's important to consider that respondents mentioned what they remembered first, so they might not have listed all the features they are aware of.

Summarizing the previous results, we can draw the following conclusion: 91.28% of schools are equipped with computer hardware, and 83.22% of teachers use it in their work. Furthermore, 75.16% of teachers use educational software (66.44% use GeoGebra). Thus, our initial sub-hypothesis is proven correct. Teachers do indeed use educational software in their work. It's worth noting that we asked the surveyed teachers each time to provide specific details about how they use both computers and educational software, to avoid random answer selection.

The next aspect we explored is the potential for popularizing the subject of mathematics by introducing innovative IT-based methods. We asked the participants to share their opinions on this matter – whether it's possible to influence current prejudices about the mathematics subject through innovative methods (Graph 5).

Table 1. Teachers' Responses on GeoGebra Features

Ability to display the appearance and construction of geometric shapes figures, and angles.
Graphing functions, geometric figures, areas of geometric shapes...
All options are mostly used for geometry.
Graphs for functions.
Drawing geometric figures, calculating areas and perimeters. Graphing functions, tangents, normals, angle measurements, side lengths, translation, rotation...
Solving equations, functions, and applications in the field of geometric solids.
Ready-made animations I used in high school, drawing geometric figures through analytic geometry (coordinate system) with parameter adjustments.
Various. There are many tutorials and pre-made examples from elementary to high school.
Drawing geometric shapes.
Basic capabilities.
All features of this software, even though I access it online.
Creating constructions of geometric shapes.
Presentation of the coordinate system.
Drawing function graphs; Isometric transformations.
Creating drawings of geometric solids.
Most features.
Graphs, geometric shapes, and solids, relationships between geometric shapes, grids of geometric solids...
I know it well enough to say 90%.
Functions and equations.
Functions, analytic geometry.
I am familiar with GeoGebra's capabilities for elementary school.
Multiple features.
The connection between algebra and geometry as calculations and visual representation of steps in certain constructions.
Basic features, enough to demonstrate within a teaching unit.
Displaying 3D objects, representing graphs and function relationships...



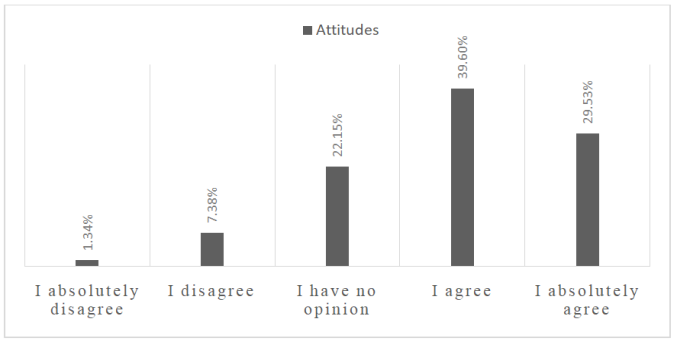
Graph 5. Teachers' Opinions on the Potential for Popularizing the Mathematics Subject Through Innovative Methods

The results have shown that 67.79% of teachers believe that through innovative methods, they can influence prejudices about the mathematics subject, indirectly affecting students' motivation towards that subject and its practical application in their daily lives. The percentage of nearly 28% of teachers who don't have a stance on this issue is somewhat concerning. Teachers are undoubtedly one of the most crucial factors contributing to changes in the teaching process and the education system. How can they be part of any reform if they lack a stance?!

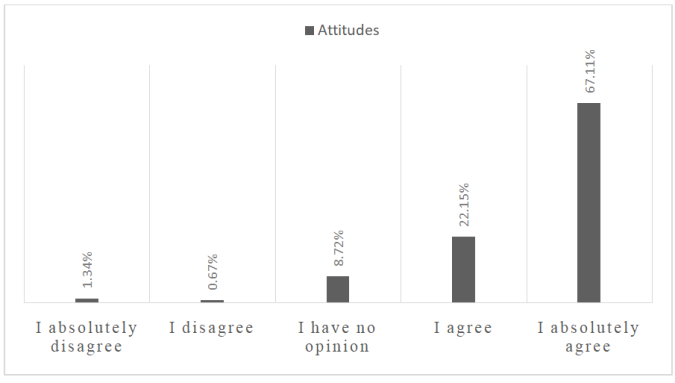
We were also interested in the teachers' opinions regarding the positive impact of using innovative teaching methods on students' acquisition of mathematical knowledge (Graph 6).

So, 69.13% of teachers partially agree with the statement. In contrast, 8.72% of teachers believe that innovative methods will not have a greater impact on students' knowledge levels compared to the currently used methods. A concerning statistic is the 22.15% of teachers who don't have a stance on this statement. There are research findings that confirm that students' knowledge is more lasting when acquired through innovative methods (Namestovski, 2013).

We wondered whether teachers are willing to introduce new teaching methods into their work. They expressed their willingness through a stance scale, which we graphically represented (Graph 7).



Graph 6. Teachers' Opinions on the Positive Impact of Using Innovative Teaching Methods on Students' Acquisition of Mathematical Knowledge



Graph 7. Teachers' Opinions on Their Willingness to Introduce New Teaching Methods

So, 89.26% of teachers are willing to innovate their teaching methods to enhance the effectiveness of their teaching. Unfortunately, 2.01% of teachers are not ready for this, and 8.72% have no stance on this topic. Summarizing the previous results, we can arrive at the following conclusion: 67.79% of teachers believe that innovative methods influence the popularization of mathematics, and 69.13% believe that they also impact students' mathematical knowledge. Moreover, 89.26% of teachers are willing to innovate their current teaching methods. We can observe that among the teachers who are open to innovations, some aren't entirely convinced

that innovative methods will influence the popularization of mathematics or students' knowledge. However, even with these doubts, they are ready to change their teaching approach. Thus, we have proven the second hypothesis as well – teachers are ready for new teaching methods based on the use of educational software.

Conclusion

The era of developing digital competencies of teachers through the application of educational software has yet to experience real expansion. It is important to constantly emphasize that high-quality digital content enables every student to play an active role in the learning process and that teaching must primarily emphasize the application of theoretical knowledge in practice. A competent teacher enjoys his work, does not waste energy on class indiscipline, has authority that students accept, and pedagogical tact that makes students satisfied in class (Žuvić *et al.,* 2016). "Caring about students' competence is the essence of all success and every feeling of joy, regardless of what one does in life. This should be the highest value of our schools. We need to make serious efforts to help students achieve a satisfying level, instead of what we are currently doing..." (Glasser, 2001). Innovativeness in education is indispensable. Without it, the entire educational system would remain stagnant and fail to keep up with the generational changes that are occurring at an increasingly rapid pace. Students must be provided with a motivating space for work and learning in which they can express their creative ideas and fully utilize their potential. Curriculum reform offers us opportunities to create such an educational system. The curriculum for mathematics, through one of its goals, emphasizes the application of technology, which is crucial at all levels of education, and connects mathematics with other sciences (Junuzović *et al.,* 2022). However, no changes are possible without teachers. If they are not ready to present the reform process, then it is doomed to failure. Guided by that, we came up with the idea of this research. The research was conducted on a sample of 149 teachers in Sarajevo Canton, Bosnia and Herzegovina. The survey was available to all teachers of mathematics and computer science, and the cause was accidental because it was not influenced in any way. For the work, the subject, problem, and goal of the research were set, and two research tasks and two sub-hypotheses emerged from them. As previously presented, we proved that teachers use educational software in their work and that they are ready to introduce innovative methods in their work. We did not examine how well teachers mastered certain software, nor in general how skilled they are in applying computers in various segments of their work. But what is currently most important is that there is an openness towards innovation, towards harmonizing their work with the needs of the time in which we live. So, we have proven that teachers are ready to improve the teaching of mathematics by introducing IT as an innovative work method, and thus improve the entire education system. This proves the main hypothesis of the work. As a recommendation for future research, it is to investigate how much help teachers need, that is, additional education when it comes to innovative work methods, and to organize teacher education based on those results. we have proven that teachers are ready to improve the teaching of mathematics by introducing IT as an innovative work method, and thus improve the entire educational system. This proves the main hypothesis of the work. As a recommendation for future research, it is to investigate how much help teachers need, that is, additional education when it comes to innovative work methods, and to organize teacher education based on those results. we have proven that teachers are ready to improve the teaching of mathematics by introducing IT as an innovative work method, and thus improve the entire educational system. This proves the main hypothesis of the work. As a recommendation for future research, it is to investigate how much help teachers need, that is, additional education when it comes to innovative work methods, and to organize teacher education based on those results. Since the work refers to the integration of ICT in elementary schools for the advancement of both students and teachers of mathematics and informatics, the conclusion is that this method should become imperative, that is, standard in our school system. By using digital and interactive content, the teacher can present many abstract mathematical concepts to students much more successfully. Through lifelong learning, teachers should make their contribution to work in more modern conditions that are changing at a rapid pace concerning the development of technology. Technology should not be just an additional material that can sometimes be useful. Technology should be an integral part of every teacher's teaching arsenal. It can be used to deepen the understanding and broaden the knowledge of students. The best mathematics teaching software integrates the use of educational software and technology as essential resources that help students understand mathematical content (Šimeta, 2021).

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