



Performing homework using of ICT for graphical presentation of trigonometric functions: A qualitative analysis

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ABSTRACT

Trigonometry is a mathematical field whose basic concepts are sine and cosine and have many different representations, some of which are covered at length in the Kosovo curriculum in high schools. Unfortunately, many of its aspects are taught procedurally, forcing students to learn without meaning and memorize formulas. The use of ICT enables the implementation of this unconventional proposal, through a series of activities. So, modern ICT provides an excellent tool to explore many of the concepts related to trigonometry, namely the graphical representation of trigonometric functions. Therefore, this study explores some of the potential of such ICTs to influence the performance of homework on graphing trigonometric functions. Qualitative research was chosen as the methodology for this study. Whereas, for this study, the selected sample is represented by about 30 students attending the eleventh grade at the music high school "Lorenc Antoni" in Prizren/Kosovo. Data collection for this study was conducted through online portfolios and an interview. The results of this study show the positive effect that ICT had on the students' motivation for doing homework during the graphical presentation of trigonometric functions.

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INTRODUCTION

Learning mathematics is no longer about memorizing formulas and procedurally solving problems, but rather, it is about how and where the acquired information can be used. Students must actively construct their understanding rather than simply absorbing what they learn. The process of learning mathematics is to promote meaningful learning for students, helping them build their knowledge so that they can develop and apply it appropriately in a variety of situations. Therefore, the use of ICT in mathematics can improve meaningful learning better than traditional classroom instruction. They can engage a wider range of intelligence, connecting the school to the real world, supporting interaction, providing dynamic displays, multiple representations, interactive models and simulations, and storing and retrieving multiple categorized information. ICT can be used to demonstrate and scaffold the development of mental models. Application programs help immediately connect graphical and symbolic representations, and make abstract concepts visible and manipulative which can help students understand the nature and application of key ideas.

One area of abstract concepts is a branch of mathematics, i.e., trigonometry. In mathematics, the basic trigonometric functions are sine, cosine, tangent, and cotangent. These functions are so useful that scientists and mathematicians always keep their importance in mind. Graphing trigonometric functions are very important and students should understand the characteristics of each. The graph of the sine trigonometric function is continuous (no breaks). The domain is defined by $-1 \leq \sin\alpha \leq 1$. The shape of the chart from $\alpha = 0$ in $\alpha = 2\pi$ is repeated every 2π radians. This is called a periodic or cyclic function, and the width of the repeating pattern measured on the horizontal axis is called the period. The sine wave has a period of 2π , a maximum value of $+1$ and a minimum value of -1 . The largest value of the sine wave is called amplitude. The graph of the cosine function is also continuous. The domain is defined by $-1 \leq \cos\alpha \leq 1$. There is a period of 2π . The shape is the same as a sine wave but shifted a distance of $\frac{\pi}{2}$ to the left on the horizontal axis. This is called a phase shift. The tangent function is $\tan\alpha = \frac{\sin\alpha}{\cos\alpha}$, consequently, that $\tan\alpha = 0$, when $\sin\alpha = 0$, and $\tan\alpha$ is undefined when $\cos\alpha = 0$. This graph is continuous, but it is indefinite when $\tan\alpha = -\frac{\pi}{2}, \frac{\pi}{2}, \frac{3\pi}{2}, \dots$. The range of values for $\tan\alpha$ is unlimited. There is a period π . The graph for the cotangent trigonometric function is very similar to that of the tangent. This similarity is simply because the cotangent of t is the tangent of the complementary angle $\pi - t$. The function is continuous in its domain. Her period is π . It is unbounded and it is symmetric. The zeros of the cotangent function are the points $\frac{\pi}{2} + k\pi$.

On the other hand, homework for high school students is a challenge in itself. However, math homework trains students to cultivate critical thinking skills, enriching their learning experience in discovering meaningful solutions through creative exploration. Another important characteristic of homework is that it provides each student with the opportunity to develop skills and think about important mathematical ideas. Homework allows students to understand what they have learned in class. Homework should be an opportunity for students to practice their skills. Therefore, in this study, we will try to get the students' perceptions regarding the performance of homework through ICT for the educational topics elaborated by trigonometry, respectively for the graphical presentation of trigonometric functions

The implementation of ICT in a mathematics classroom can help students to adopt an attitude that will enable them to improve their mathematics learning. (Albelbisi & Yusop, 2018). One of the most visible changes in mathematics education over the past 20 years has been the shift towards the use of ICT. Many students in high schools now view their homework problems on screens through tools like ASSISTments and Khan Academy, and present their solutions through screens as well. This shift to technology comes with some significant advantages: students can get instant feedback on homework; software can model student progress (Hinkley, Heffernan, & Lee Bou, 2020). According to Raci (2020), the COVID-19 pandemic in our country was a good opportunity to understand the importance and priority of using ICT in teaching and to take concrete measures in the construction

and inclusion of online learning in education system of Kosovo (Raci, 2020). The total number of students in Kosovo from public preschool education to public pre-university institutions is 466,439, children and students, with a total of 23,262 teachers for the year 2018/2019, who were affected by the closure or temporary suspension of educational institutions starting from kindergartens, schools, and universities (Morina, 2020).

Cox (2011) noted that the usefulness of homework can be achieved if it is graded. Therefore, introducing ICT is a promising way to provide effective homework assignments that are automatically graded and thus provide immediate feedback. (Albelbisi & Yusop, 2018; Kelly, et al., 2013; Sarmiento, 2017). Web-based homework (WBH) is a relatively new teaching tool that some mathematics teachers use in the teaching process (Albelbisi & Yusop, 2018; Elmehdi, 2013). Students can do their math homework with the help of web-based tutorials and get instant feedback (Leong & Alexander, 2014). The results of the Roschelle, Feng, Murphy, and Mason (2016) study showed that the ICT intervention significantly increased student scores on a standardized end-of-year math assessment compared to a control group that continued with existing homework practices. Students with low prior achievement in mathematics benefited more. The authors note that the intervention has the potential for wider adoption (Roschelle, Feng, Murphy, & Mason, 2016).

Trigonometric functions are one of the most important topics of mathematics related to algebraic, geometric, and graphical reasoning, which can be manipulated using the dynamic software GeoGebra, which can serve as an important precursor to understanding preliminary calculus and calculus (Weber, 2005). As pointed out by Duval (1999), there is no meaning to mathematics without visualization. Visualizations are intended to be concrete tools that enable students to explore more difficult mathematical concepts. The representations and symbols of mathematics create a semiotic system that is of fundamental importance to any mathematical activity (Chiappini & Bottino, 1999). Therefore, in addition, ICT was a dynamic visual mediator that facilitated students' engagement in inductive processes that helped them arrive at an understanding of trigonometry. These inductive processes were mediated by the GeoGebra program. Also, through this, students could pay attention to the properties of trigonometric functions and thus could compare these properties in different intervals (Daher, 2020). In the study of Balandra (2022) a significant relationship was observed between the subject's personal confidence and the level of proficiency in trigonometry (Balandra, 2022).

According to authors, Naidoo and Govender (2014) ICT allowed students to receive immediate feedback and this helped motivate and increase students' confidence levels when graphing trigonometric functions. In addition, ICT provided a platform for students to communicate after school hours. Through active participation in the lessons, students achieved and demonstrated a concrete understanding of the graphs of trigonometric functions (Naidoo, 2014). The findings of the study of the author Mokoena (2022) justified the formulation of the strategy to improve the teaching and learning of trigonometric functions using ICT (Mokoena, 2021). According to Pfeiffer's (2017) study, 11th-grade students reported that using ICT helped them understand the properties of basic trigonometric functions and in turn the effects of parameters (Pfeiffer, 2017).

PURPOSE OF RESEARCH

In this study, we have tried to motivate the students in completing their homework with the help of ICT. Trigonometry has been described as the most difficult part of the high school math curriculum, and students find it very challenging and difficult. Therefore, our aim was that through the use of ICT, students complete their homework while presenting trigonometric functions. Despite all efforts done so far, challenges persist in improving the teaching process in the subject of mathematics through the assistance of ICT. Trigonometric functions are abstract concepts, and students struggle to accurately sketch, read, and interpret graphs of trigonometric functions, taking into account the effects of parameters. Therefore, in this study, the analysis of the role of ICT is examined based on the experience developed in the assessment of homework related to the graphic presentation of trigonometric functions. This analysis is also based on the study of students' perceptions which investigated the role of ICT in mathematics education from different perspectives.

Specific objectives

1. What is the role of ICT in the presentation of homework when graphing trigonometric functions?
2. What are the students' attitudes towards the use of ICT in doing homework for the learning topics of trigonometric functions?
3. What perceptions do students have about doing homework while presenting trigonometric functions with the use of ICT?
4. How do help ICT in homework on graphing trigonometric functions?

METHODS

Design

This study is designed as qualitative research. Qualitative research is deemed to be suitable for it explores and understands the unique experiences of the participants in order to construct the meaning of the phenomenon by capturing and interpreting what are the influences of ICT while doing homework (Dela Fuente, 2021). In this study, the researcher wanted students to explain their thinking process when they decide to either try to complete or completely ignore their homework with the use of ICT. One of the most powerful aspects of qualitative research is its ability to capture personal experiences, provide a voice for participants, and present findings in a variety of formats (Onwuegbuzie & Leech, 2005; Prakash, 2007).

Participants

For this study, the selected sample is represented by about 30 students attending the eleventh grade at the music of high school "Lorenc Antoni" in Prizren/Kosovo who qualified for the inclusion criteria set by the researcher. The inclusion criteria is a set of guidelines for whom will be qualified as participants of the study that can provide essential meanings to the experiences shared by the participants (Dela Fuente, 2019). The selected sample is a purposive sample since trigonometric functions are taught in the Kosovo curriculum in this class. The selected students are from the 3 parallels of this school from the 2021/2022 school year.

Instrument and data collection

Data collection for this study was conducted through online portfolios and an interview. The online portfolio served to check if the students have done their homework well. The collection of materials from the students was done in a separate folder in Google classroom, where the students posted their tasks and then the teacher evaluated the completed task. This activity lasted about four weeks, as the teaching topics for the four main trigonometric functions sine, cosine, tangent, and cotangent were covered. Initially, the students were presented with some software where they can visually present these functions, but they were free to choose the most suitable application program. On the other hand, the interview served to obtain the students' perceptions regarding the completion of homework with the help of ICT. The interview was structured with open-ended questions and distributed online through Google classroom designed with Google Forms which is gaining popularity as a common instrument for data collection nowadays.

Data analysis

Data analysis for this study was done through the NVivo program and the qualitative data collected were interpreted manually. Through this procedure, the available data was read, and repeated or commonly used words were found. The techniques used for qualitative data analysis is content and narrative analysis. Using of content analysis, it was used to determine the presence of certain words, themes, or concepts within the students' answers about the use of ICT for homework related to the graphical presentation of trigonometric functions. On the other

hand, the narrative analysis served us to understand how the students participating in this research describe their personal experiences while using ICT in doing homework. They are then interpreted narratively.

FINDINGS

Before the availability of ICT, graphing trigonometric functions was a tedious task for students, with little practical purpose. ICT is now providing a mechanism to draw graphs much faster, which allows students to compare graphs to gain some insight into the nature and differences between functions. Below we present some of the students' homework completed with the help of ICT in the graphical presentation of trigonometric functions:

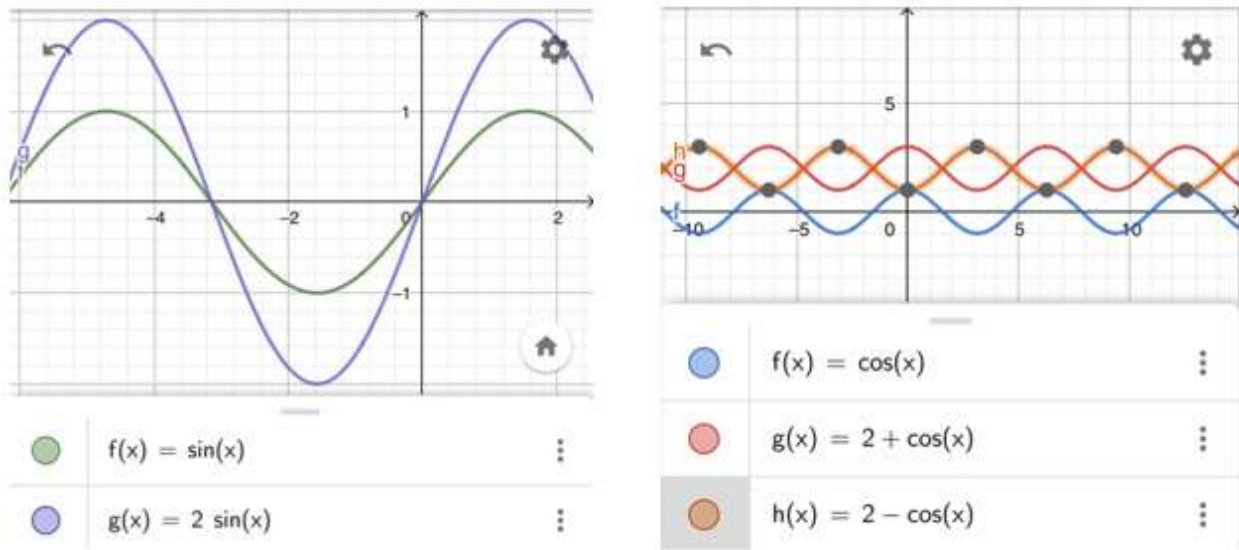


Figure 1. Graphical presentation of sine and cosine trigonometric functions with the help of ICT

In figure 1, we see how the students presented the graph of the trigonometric functions $f(x) = \sin x$, $g(x) = 2 \sin x$, as well as the graph of trigonometric functions $f(x) = \cos x$, $g(x) = 2 + \cos x$, $h(x) = 2 - \cos x$ through the use of ICT. From all this, we see that students are able to easily present any graph of a trigonometric function and explore them by tracing or using automatic procedures to explore key points, noting periodicity, amplitude, etc. Before such a strategy, students performing these tasks usually had less experience in graphic representation. This is shown as a good example of exploring a graph of a trigonometric function to find the zeros of functions, extreme values, etc.

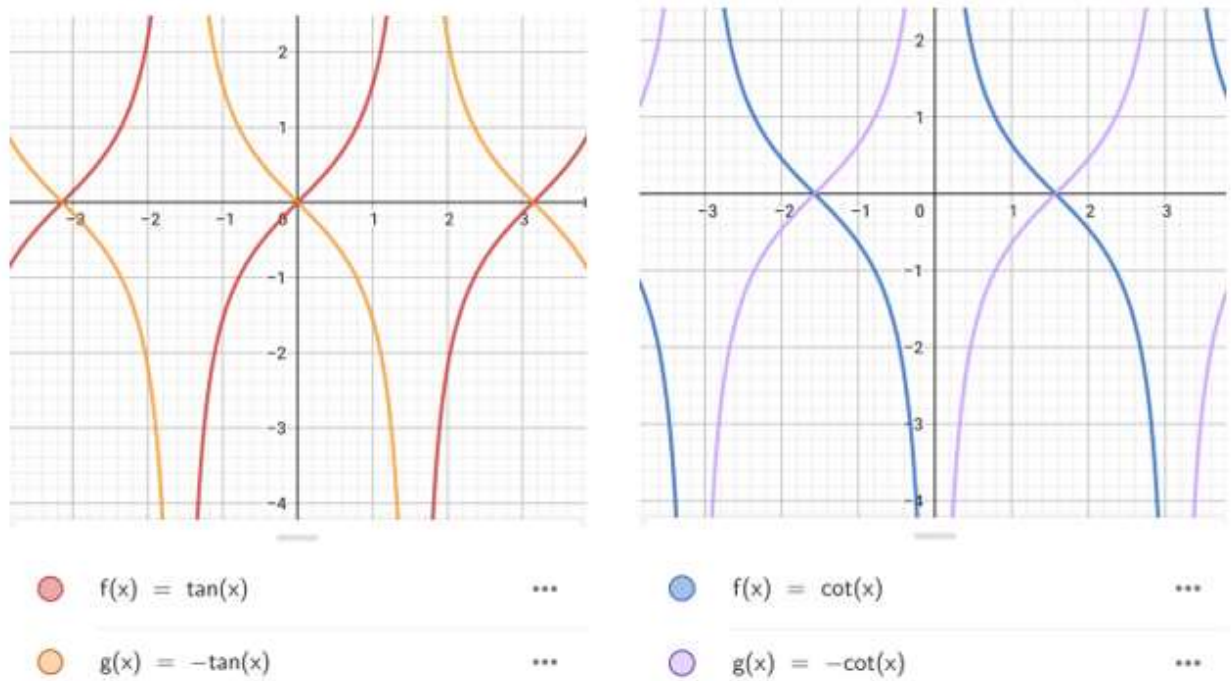


Figure 2. Graphical presentation of tangent and cotangent trigonometric functions with the help of ICT

In figure 2, we see how the students presented the graph of the trigonometric functions $f(x) = \tan x$, $g(x) = -\tan x$, as well as the graph of trigonometric functions $f(x) = \cot x$, $g(x) = -\cot x$ using ICT. The online portfolio was a good way for students to see and share their homework achievements over time. Homework for graphing trigonometric functions was further analysed and graded. Something that was noticed when handing in the homework was that most of the students had a willingness and motivation to do their homework, as this does not show up in the homework notebooks. As we mentioned in the data collection section, the interview served us to obtain the students' perceptions regarding the use of ICT in performing homework for the graphical presentation of trigonometric functions. Below we present the frequency of words developed from the interview:

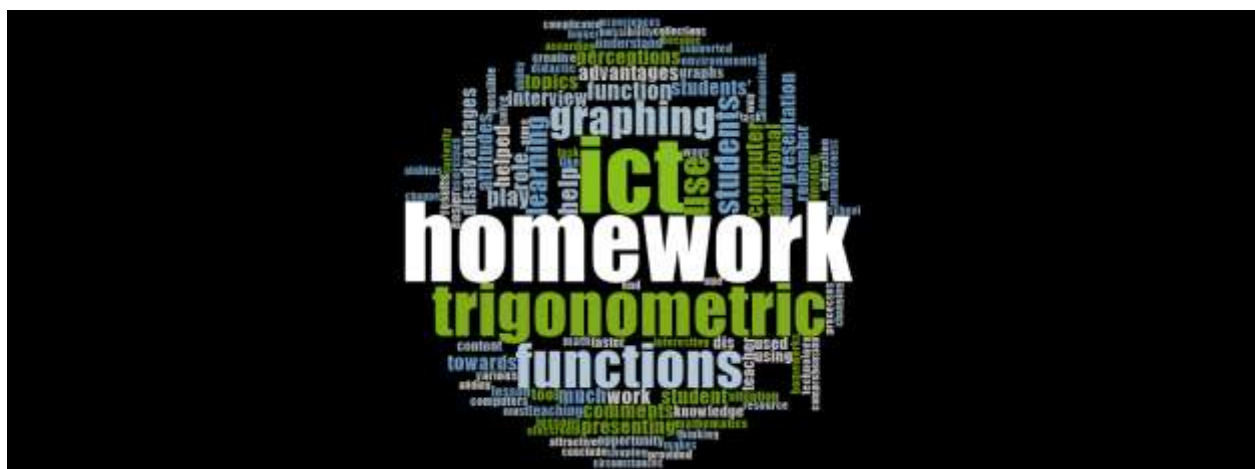


Figure 3. Frequent presentation of words from the interview

Also, the following findings emerge from the interviews of the students for the questions presented. For the first question, how much has ICT helped you in doing your homework, they declare that ICT has helped them

do their homework faster, and easier, some students indicated that it contributes to doing their homework independently, in groups, and some clarify that it increases efficiency, understanding of topics, increasing self-confidence, as well as one student confessed that ICT was a facilitating tool to complete homework, etc. Regarding the question of what role ICT plays in presenting homework when graphing trigonometric functions, they answer that ICT is changing the process of the mathematics lesson by adding elements of vitality to home education environments, including virtual environments for this purpose. Also, the students think that ICT can develop creative thinking, it is playing an important role because it does everything for us, the students say. A student shows that he is giving fast pace and accuracy in his work. Another student shows that ICT is giving the possibility of observing the process of creating graphs and the possibility of comparing several trigonometric functions at the same time. It is playing a role in recalling mathematical rules, understanding the trigonometric functions as easily as possible, and cooperation between friends and the teacher, where cooperation activities were visible, the students say. As for the third question, what are the students' attitudes towards the use of ICT in doing homework on the learning topics of trigonometric functions, the students indicate that the purpose of homework supported by ICT is interdisciplinary, more advanced than the goals of traditional duties. It is helping to develop critical thinking, presents a positive attitude towards problem solving and research, explains tasks with simple examples, and homework is represented as a game, students confess. Another student points out that ICT is helping to understand the processes, not just finding the result. Also, students say that ICT has helped them to visualize the graph of trigonometric functions, more activity, as well as improve their skills and abilities. For the fourth question, what perceptions do students have about doing trigonometric function presentation homework with the use of ICT, they state that they have positive perceptions about doing homework with ICT for the graphic presentation of trigonometric functions. A student claims that doing homework with ICT is more interesting. Others indicate that they were very quickly used to completing their tasks with ICT, and they looked at the graph of the presented trigonometric function, as well as greater motivation to complete the tasks. In the next question, how does ICT help for graphing trigonometric functions homework, the students say that ICT is helping to develop the understanding of the tasks by visualizing the content. They also show that ICT is helping to make the content offered more attractive, but still, a student presents a problem that ICT should be used according to the age of the students. However, others confess that they very quickly present the graph of the given trigonometric function, since this procedure is done only by noting the formula. Also, they show that with ICT it was possible to present several tasks in the same coordinate system. They were satisfied with the use of ICT in solving homework. In the question, what are the advantages and disadvantages of doing homework with ICT, students have more advantages of using ICT in doing homework than those disadvantages.

The advantages cited by the students were that ICT enables them to solve homework in different ways, then they are becoming more curious, better assessment of homework is being done, creating the graph and filling the data table automatically, with ICT knowledge structuring was being done, excellent homework helper. However, some presented the disadvantages of doing ICT homework for trigonometric functions. Some of the disadvantages were that they claimed to have to examine the graph of the function themselves, while others stated that the students copied each other's homework. A student presented a problem that not everyone has good skills to use ICT for homework. Some did not like doing homework with ICT and they point out that it was a difficult task. In the last question posed to the students, what additional comments do you have about graphing trigonometric functions in homework using ICT, they expressed their comments stating that with ICT they sought new knowledge and drew general conclusions. Among the additional comments was that ICT brought them a new experience. They show that with ICT it was possible to more easily find the domain, zeros, extreme values, period, and many other points presented in the visualization of the trigonometric function. Another comment was that it enabled them to take on additional tasks and they achieved higher scores on tests. Therefore, ICT is proving to be somewhat of a game changer in the effectiveness of homework in new circumstances and should be encouraged in continued use for homework. Below we are summarizing in a table the completed interview with the participating students for this study about the use of ICT in doing homework for the graphical presentation of trigonometric functions:

Table 1. Students' perceptions of homework using ICT for trigonometric functions

Categories	Keywords	Propositions
ICT has helped them do their homework faster and easier	Quickly; easily	
ICT contributes to the performance of tasks independently and in groups	Independent; individual; group	ICT help in doing homework
Homework with ICT increases efficiency and self-confidence	Efficiency; confidence	
Homework with ICT helps understanding topics, problem solving and higher test scores	Help; understanding; problem solving; higher scores	
Homework with ICT includes virtual environments and explains tasks with simple examples	Virtual environment; clarify; simple examples	Visualization of the graph of the trigonometric function
Homework with ICT observes the process of creating graphs and the possibility of comparing several functions at the same time	Observation; comparison	
Homework with ICT creates the graph and completes the table, as well as presents several tasks in the same coordinate system	Creates the chart; completes the table several tasks	
Homework with ICT gives fast pace and accuracy in work	Fast pace; accurately	
Homework with ICT is represented as a game, students are told and it is more interesting	Game; interesting	Positive perceptions
Homework with ICT has a positive attitude and greater motivation to complete tasks	Positive attitude; greater motivation	
Homework with ICT solves the tasks in different ways and the best assessment of these tasks is done	Select; different ways; evaluation	
Homework with ICT becomes the content provided is more attractive and gets additional tasks	Attractive; take on additional duties	Assistant for performing tasks
ICT was a great assistant in doing homework	Assistant; fine	

ICT brought them a new experience, as well as cooperation between friends and teachers

Experience;
collaboration

Moreover, according to table 1, we are noticing that the participating students are showing the help and role that ICT has in doing homework during the graphic presentation of trigonometric functions, and they are also having positive perceptions about doing these tasks with ICT. Therefore, in the following, we are opening the discussion regarding the analysed results.

DISCUSSIONS

A very important key to understanding mathematics is the use of visualization and representation in the learning and teaching process. Additionally, one of the visualization requirements is required when displaying trigonometric functions. There are several ways to represent trigonometric functions. In this study, the presentation of these functions was realized through the use of ICT. Also, the presentation of these tasks through ICT has been investigated through the performance of homework by the students participating in this study. Using ICT in mathematics homework can be a challenging task for many students. However, in this study, they welcomed ICT assistance in their tasks very well and there was a wide variety of experiences. Also, ICT is supporting the teaching-learning environment in a constructivist approach. On the other hand, homework done with the traditional pencil-and-notebook approach has many limitations for teachers. The main limitation is related to the assessment of all students' homework.

The results of the study show that the role of ICT in doing homework was vital and that students emphasize the importance of using ICT in doing these tasks. This is also proven by the responses of the students participating in the interview, which show that homework with ICT is observing the process of examining and graphically presenting trigonometric functions, as well as the possibility of comparing several functions at the same time. Also, from the review of the literature, we have found many papers that present the role of ICT in homework for these educational topics. Authors Mosese and Ogbonnaya (2021) show that in terms of the interpretation and analysis of trigonometric functions, the study conducted with two groups of participants, it states that the experimental group was found to have performed significantly better than the control group (Mosese & Ogbonnaya, 2021). Also, in my previous study by Orhani (2021) it was proven that students had positive perceptions of the integration of ICT in mathematics lessons (Orhani, 2021). Here we can conclude that the use of ICT was effective in improving students' ability to interpret and analyse trigonometric functions. Therefore, we can support our study objectives as it is proven that ICT is having an important role in the presentation of homework during the graphing of trigonometric functions.

Regarding the purpose of our study about understanding students' attitudes, the role of ICT in mathematics education was investigated from different perspectives. Our findings show that ICT brought them a new experience and was an excellent assistant in completing their homework on representing trigonometric functions. Likewise, the findings of studies by Paudel (2015), Curri (2012), Abdullah et al. (2015) show that students have positive attitudes toward the use of ICT in mathematics (Paudel, 2015; Curri, 2012; Abdullah, Ziden, Aman, & Mustafa, 2015). The findings of our study and the mentioned studies provide information for teachers that students are interested in using ICT in the performance of their tasks. Therefore, the attitudes of students towards the use of ICT in the performance of homework for the teaching topics of trigonometric functions indicate the fulfillment of the objectives of this study, as it is proven that there is a perfect relationship between the attitudes of the students towards the performance of these tasks with ICT.

In this study, we found modest positive perceptions from students who stated that doing homework with ICT was motivating and satisfying. Likewise, the results of this study show that homework with ICT was represented as a game and was more interesting to complete. On the other hand, other studies such as by the author Serhan (2019) show that students perceive that ICT-based homework systems have a positive impact on their learning experience in the classroom. Another study by the author, Brewer (2009), shows that our findings are

consistent with the study conducted by the author and that students may already have formed such good perceptions of mathematical skills in completing ICT homework perfectly (Serhan, 2019; Brewer, 2009). Therefore, from the findings, we are noticing that we can answer the objectives of the study that students have positive perceptions about doing homework for the presentation of trigonometric functions with the use of ICT.

One of the most important findings in this study was that ICT helps students in doing homework and has an effect on increasing learning outcomes for these learning topics. These findings are parallel to the findings of the authors Roschelle, Feng, Murphy, and Mason (2016) in the study about online homework in mathematics increase the achievement of students, where the results showed that the intervention significantly increased their achievement in a standardized assessment of mathematics in the end of the year compared to a control group that continued with existing homework practices (Roschelle, Feng, Murphy, & Mason, 2016). Also, the study by the authors Öngün and Demirağ (2015) points out that ICT acts as a catalyst for an interactive and collaborative achievement of homework (Öngün & Demirağ, 2015). Therefore, from our study findings and the mentioned studies we can answer our question that ICT helps in doing homework for graphing trigonometric functions.

IMPLICATIONS

Our findings proved to be important for many mathematics teachers because homework is a common policy of teachers and students who often criticize the value of their existing practices. Specifically, this study showed a way to improve the value of homework through the use of ICT. The results of this study showed that ICT helped with homework on trigonometric functions and had significant effects on student achievement. Also, the general perceptions of the students drawn from this study are generally positive towards the use of ICT in performing homework for the graphical representation of trigonometric functions.

ICT-assisted homework made students motivated and successfully complete these tasks through exploration and active participation rather than the traditional method of completing tasks with a pencil in a notebook. The study showed that students were more engaged in this process and ICT proved to have an important role in presenting and reviewing trigonometric functions. Also, the implications of our study are supporting the initiative of the Ministry of Education in Kosovo which approved the Pre-University Curriculum Framework, which expresses the need to move to the digital age and states that digital skills and competencies should be the result of schools. Therefore, in this study, the use of ICT for homework on graphing trigonometric functions produced a positive impact on the successful completion of these tasks. This study can encourage mathematics teachers to create contemporary teaching practices with teaching theory concepts through the use of ICT. However, mathematics teachers should not necessarily require students to use only ICT to present trigonometric functions. This study also encourages the adoption of ICT in homework that supports the development of the students' motivation level to complete the tasks in the subject of mathematics.

RECOMMENDATIONS

But the question is also raised as whether it is better to use traditional or modern tools. You can use these tools while holding students accountable by making pencil and paperwork an expectation, then verify the accuracy of these tasks with ICT. Other studies can be conducted to see how this study can affect other countries, undeveloped issues to do homework on the appearance of trigonometric functions. Likewise, it can be studied which necessary conditions must be met for teachers. Authors Agasisti, Gil-Izquierdo, and Han of different countries in their studies and we recommend that these findings suggest that a more careful approach should be taken regarding the use of ICT to present trigonometric functions in homework (Agasisti, Gil-Izquierdo, & Han, 2017). Such an indication could potentially suggest that teachers should integrate this practice effectively into their homework assignment strategies.

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