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READINESS OF UKRAINIAN MATHEMATICS TEACHERS TO USE COMPUTER GAMES IN THE EDUCATIONAL PROCESS

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Abstract. The paper presents the opinions of mathematics teachers regarding expediency and possibility of using computer mathematical games in the educational process. The survey was conducted in urban and rural schools of Ukraine in 2019 (sample size – 48) and 2021 (sample size – 55). Teachers of all age categories and levels of school education (primary, secondary, senior secondary) were involved. As a result of the study, the growing interest of Ukrainian mathematics teachers in computer mathematical games was noted after long-term online learning during quarantine measures on COVID-19. Moreover, some teachers already use computer mathematical games to develop the knowledge and skills of both students (15%) and their own children (40%).However, every fifth teacher does not consider it necessary to use electronic games in mathematics lessons. In general, there is a trend towards their implementation at various levels of education: from school to future teachers training faculties, but there are still a number of unresolved important issues, including didactic ones.

Keywords: computer mathematical games; mathematics teachers of Ukraine; using computer mathematical games; implementation of computer games

1. Introduction

Nowadays, children of all ages are fascinated by computer games and gadgets in different countries, that is gradually becoming the norm of modern society.We are talking about countries that are sufficiently equipped with information technologies at such a level that almost every family with children has a smartphone, laptop or computer, or all these devices together. Currently, Ukraine belongs to such countries, and the number of children who can not tear themselves away from mobile phones (games, social networks, etc.) is many times greater than the number of children who are not interested in various applications and computer games. The number of video game users worldwide is expected to reach 2,829.8 millions by

2027. The largest segment is mobile games with a market volume of US 164.10 billions in 2022 (Statista. The Statistics Portal 2022).

In addition, we pay attention that the issue of using computer games in education has been solved in the works of researchers from the USA, Australia, Canada, Great Britain, etc., during 40 years. The term "serious games" was first used in 1970 byAbt for the title of a book of the same name. Today's "serious computer games" are games that are not used for entertainment, but for learning or training, and education is one of such application area (Susi 2007). This approach formed the basis of the concept development of Game Based Learning– the use of video games in education. The famous American expert in the field of education with the help of video games Gee laid out his main ideas and arguments in favor of learning with the help of video games in the work "What Video Games Have to Teach Us About Learning and Literacy". He formulated Gee's Video Game Learning Theory (Gee 2003).

In many developed countries of the world, the implementation of serious computer games into the process of learning mathematics is not considered an innovation.Scientists conduct thorough studies of the influence of computer games on the process of learning mathematics for students of different age groups, in particular:

– primary school (Abdullah et al. 2012; Kickmeier-Rust et al. 2014; Mahmoudi et al. 2015; Munoz & El-Hani 2012; Perez et al. 2018; Russoet al. 2021and others);

– secondary school (Abrams 2008; Es-Sajjade & Paas 2020; Ibrahim & Abu Hmaid 2017; Vogel et al. 2006; Wouters et al. 2013 and others).

Most researchers note the positive impact of computer games on the process of learning mathematics for primary and secondary school students.Thus, in 2014, Austrian scientists conducted a study that focused on determining the level of mastery of mathematics by primaryschool students using the game program SonicDivider. This study showed that it was much more interesting for students to perform tasks in game activities than on the basis of traditional worksheets, and the level of knowledge increased (Kickmeier-Rust et al. 2014).

Spanish scientists conducted a study on the implementation of the "Game to Learn" project primary school students, the purpose of which was not only to promote the use of electronic video games in the educational process, but also to analyze the results of the students' educational activities. After the appropriate analysis, the scientists came to the conclusion that such games have a positive effect on the level of knowledge acquisition of students in logical-mathematical, naturalistic and linguistic fields (Perez et al.2018).In the same time Mahmoudi et al. (Turkey) claim that computer games have a positive effect on improving the concentration of attention and the speed of maths calculations of primary school students (Mahmoudiet al.2015).

The results of the research by Ibrahim& Abu Hmaid (Jordan), Es-Sajjade &Paas (Great Britain) showed that the educational environment in mathematics using com-

puter games has a positive effect on the success in mathematics of the fifth-sixth grade students (Ibrahim& Abu Hmaid2017;Es-Sajjade&Paas 2020).American researchers also note the positive influence of using educational computer games on the performance of secondary school students in mathematics (Abrams 2008, Wouters et al. 2013). Moreover, Wouters et al. conducted an additional analysis of learning effectiveness, which showed that the use of computer games in combination with other teaching methods(in particular, when players work in groups) gave an even better result (Wouters et al. 2013).Besides, Brazilian researchers Munoz& El-Hani see the potential of computer games in participants' acquisition of conceptual, behavioral and operational learning content (Munoz& El-Hani 2012).

Earlier studies on the use of computer games in the educational process focused on comparing Game Based Learning with traditional teaching methods (O'Neil et al. 2005; Wouters et. al2008). Recently, more and more scientific publications raise the question of the place and role of a teacher in the Game Based Learning environment. In particular, Malaysian researchers state that although teachers are not against the idea of using computer games in teaching mathematics, most of them consider the traditional teaching of mathematics as a better approach, and consider computer games as additional learning tools (Yong et al. 2016).

The changes, that have taken place in education around the world in connection with the COVID-19 coronavirus pandemic, have raised the issue of the use of computer mathematical games in the conditions of distance learning(Alabdulaziz 2021; Jordaan et al. 2021).

In particular, Alabdulaziz examined the question of whether COVID-19 has become a catalyst for digital learning, including and the use of gamification in mathematics education. The study found that 98% of respondents (mathematics teachers) believe that COVID-19 has opened the way for the gamification of mathematics learning and that the use of computer games has increased significantly since the beginning of the pandemic (Alabdulaziz 2021).

In the works of Ukrainian researchers, pedagogical conditions of use the computer games in the educational process (Kyrylenko 2007), certain aspects of the use of computer games in mathematics lessons (Luk'yanenko 2014) are considered. However, we did not find any publications by Ukrainian researchers covering experimental studies on the effectiveness of teaching mathematics using computer mathematical games, the place and role of the mathematics teacher in the organization of such an educational process. The use of computer games is considered mainly for the purpose of forming students' cognitive interest in studying the subject (motivation of learning) and is not analyzed by researchers as tools of increasing success and quality of learning (Bevz et al. 2014).

Thus, we consider it expedient to conduct research related to the study of the place and role of the mathematics teacher in the organization of the educational process with the use of computer mathematical games, the interests of mathematics

teachers in Ukraine who plan to use mathematical computer games in order to improve efficiency and quality teaching mathematics. In addition, this issue remains understudied in Ukraine.

The purpose of this study was to investigate how common is the use of computer games in the process of teaching mathematics in Ukrainian schools, in particular, to study the opinions of mathematics teachers regarding the expediency and possibility of using computer mathematical games in their work.

2. Methods

A descriptive, comparative, self-administered questionnaire-based study was carried out with a 2-year interval among teachers of mathematics from three regions of Ukraine: Vinnytsia region, Chernivtsi region, Kherson region. The first survey was conducted in November 2019 (the size of sample was 48), the second – in March 2021, after a year of forced online learning due to the pandemic (the size of sample was 55). The content of the questionnaire was the same, without changes.

The first part of the questionnaire related demographic data of the respondents, such as gender, age, educational institution. The second part of the questionnaire aimed to find out how much mathematics teachers know about available computer mathematical games, to determine the real state of implementation of computer mathematical games in the educational process and to reveal teachers' interest in using computer mathematical games in teaching mathematics. Respondents had the opportunity to choose several answers to some questions, as well as express their own comments. The questions related to teachers' opinions about the possibility of using mathematical computer games in lessons, choosing the purpose of their using, and also about where it is better to get the necessary didactic information on this matter.

Each respondent voluntarily agreed to participate in the survey and was informed about anonymity.

In 2019, the survey was conducted offline in educational institutions, in 2021 – online using Google Forms.

Statistical data processing was carried out using the Microsoft Excel program. Data were analyzed using descriptive statistics.The age is presented as mean and standard deviation.

3. Results

Demographic data of the respondents

48 Ukrainian mathematics teachers took part in the initial survey in 2019: 29 teachers were from Vinnytsia region, 10 – from Chernivtsi region, 9 – from Kherson region. 55 mathematics teachers from Vinnytsia region took part in the second survey in 2021.

Women made up the vast majority of mathematics teachers (Table 1). The age

of respondents was (45 ± 11) yearsin the first sample and(44 ± 11)yearsin the second. The number of respondents who worked an urban or rural school roughly corresponds to the general picture of such a proportion in Ukraine (Samokhin 2019). In particular, in 2019 and 2021, 72.92% and 74.54% were working in urban schools, 20.83% and 21.82% – in rural schools, 6.25% and 3.64% – in urban-type settlement' schools, respectively.

Table1.Demographic data of the respondents in two samples

Survey year	Gender of respondents								
	Male, %			Female, %					
2019	18.75			81.25					
2021	14.55			85.45					
Survey year	Age of teachers, n								
	21 – 25 years	26 – 30 years	31 – 35 years	36 – 40 years	41 – 45 years	46 – 50 years	51 – 55 years	56 – 60 years	61 year and older
2019	2	4	7	3	8	8	6	8	2
2021	3	5	6	7	7	12	4	7	4

Survey year	Classes in which mathematics is taught, %			
	Primary school, 1 – 4 grades	Secondary school, 5 – 9 grades	Secondary and senior secondary schools, 5 – 11 grades	Senior secondary school, 10 – 11 grades
2019	10.42	31.25	58.33	–
2021	7.27	20.00	63.64	9.09

Implementation state of mathematical computer games and teachers' attitude towards them

The first questions of the second part of the questionnaire generally outlined the situation regarding the practical interest of mathematics teachers in electronic games. It turned out that the majority of interviewed teachers are not too fond of computer games in their everyday life, and almost all older teachers (50 – 60 years old) do not play them at all. Moreover, the situation was similar in both surveys (Figure 1).

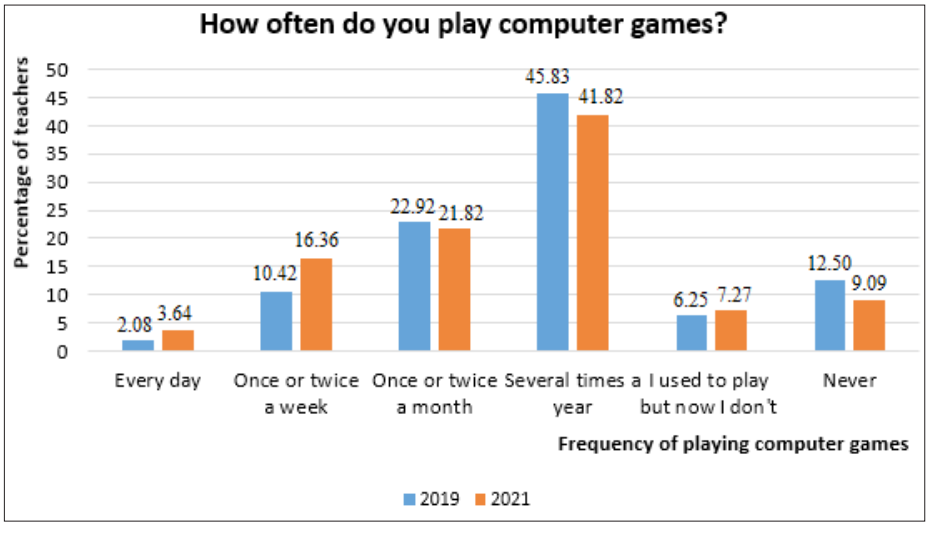

Figure1. Percent age distribution of mathematics teachers by the frequency of playing electronic games

Professional interest in computer games has changed somewhat after forced online learning in schools, which was caused by the coronavirus pandemic.In 2021, the number of teachers who were interested in electronic mathematical games and tried to play them increased significantly.Accordingly, the number of teachers who have heard about such games, but have not found anything special and worthy of attention in them, has decreased.The number of respondents wanting to learn more about computer mathematical games has increased, as well as the number of teachers who consider such games as an educational tools (Table 2).

Table2. Teachers' interest in electronic mathematical games

Answer option	The first sample: 2019, %	The second sample: 2021, %
Have you ever been interested in electronic mathematical games?		
Yes, I have. I have been interested and I have played	6.25	23.64
Yes, I have. I have been interested and have used them for the development of my own children	39.58	40.00
Yes, I have. I have been interested but have not found anything worthy of attention	45.83	29.09
No, Ihavenot. I heve not been interested and I have not heard about them	8.33	7.27

Would you like to learn more about computer mathematical games?		
Yes	58.34	70.90
Maybe	33.33	23.64
No	8.33	5.45
Can a computer mathematical game be considered an educational tool?		
Yes	37.50	43.64
Maybe	45.83	45.45
No	16.67	10.91

Confirmation that teachers consider electronic games as aneducational tool are the answers to the following question: "If we were talking about the implementation of computer mathematical games into the educational process from the next academic year, for what purpose, in your opinion, would it better to use them?".And let's pay attention that the goal "for development of existing knowledge and skills" took first place(figure 2).

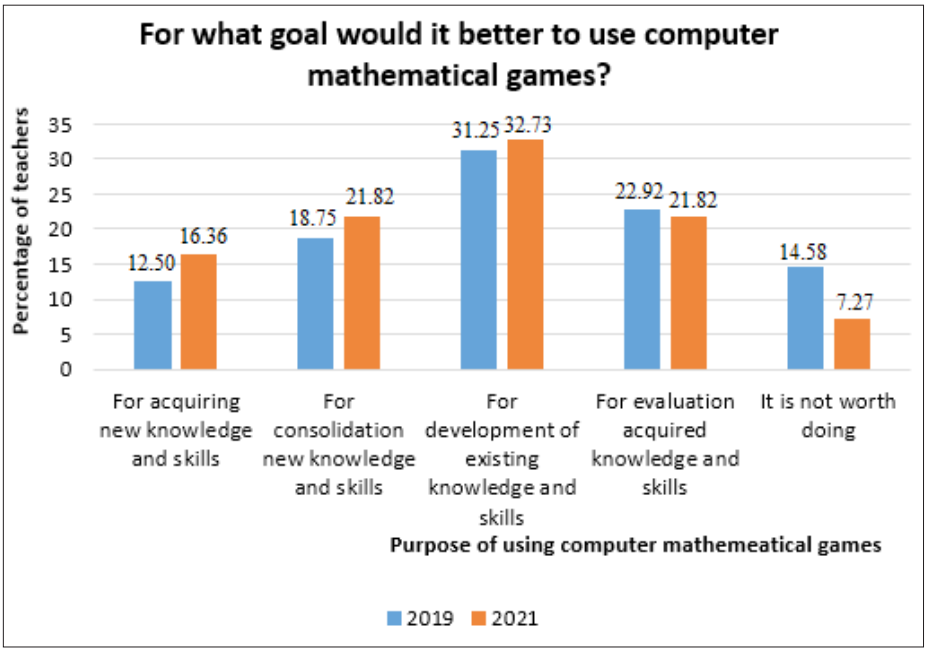

Figure 2.The purpose of using computer mathematical games through the eyes of teachers

The willingness to obtain new information from the use of computer mathematical games during education, on the one hand, and the understanding of their possible effectiveness as a tool of learning, on the other hand, raise another component of the investigated problem: "where to get the necessary information for a teacher of mathematics?". Answers to a similar question showed that teachers trust official government sources more (in-service teacher training courses) while simultaneously looking for additional online sources. In particular, in 2019 and 2021, respectively, teachers preferred to receive information about the possibilities of using computer games in mathematics lessons as follows:

– at in-service teacher training courses: 60.42% and 40.00%;
– on the Internet, performing an independent search:12.50% J492
and 16.36%;
– at webinars, trainings:12.50% and 23.64%;
– at online courses:10.42% and 18.18%;
– from other sources of information: 4.17% and 1.81%.

Additional information on the research question was obtained from the last two questions of the questionnaire, where the answers had a more personal color. Teachers could choose several answers (Table 3) and express their own opinions about the expediency of using electronic mathematical games in the process of teaching and learning mathematics. In particular, some teachers have listed the electronic resources that they used in their own activities, have indicated the advantages and disadvantages of their use.

Table3. Attitudes of teachers towards the use of computer mathematical games

Answeroption	Thefirstsample: 2019, %	Thesecondsample: 2021, %
Choose the statements that apply to you		
a) I know there are "great" computer mathematical games that are good for learning, but I have not used them in my own work practice	39.58	52.73
b) I use computer mathematical games in my own practice and am satisfied with the result	10.42	14.55
c) I assume that the use of computer mathematical games can be useful for both the teacher and the students	87.50	78.18
d) I doubt that it is possible to acquire the necessary knowledge and skills in mathematics with the help of computer games	33.33	7.27

e) I am a supporter of traditional teaching of mathematics (without computer games)	12.50	9.09
f) I think that using computer games to learn mathematics is just entertainment for students and a waste of learning time	12.50	5.45

4. Discussion

The important factor for analysis and conclusions on the researched issue is that teachers of different age categories took part in the study. Considering that older people (especially after 50) have little interest in digital technologies, we assumed that a similar situation would apply to mathematics teachers. And indeed, in 2019 and 2021, a certain percentage of teachers (about 10%) who gave negative answers to all questions of the questionnaire are observed. They were older teachers who categorically denied the possibility of using computer games in learning and teaching mathematics, accordingly did not consider them as a tools of learning and did not show a desire to learn more information.

In contrast, the younger generation of teachers is more confident in exploring possible game applications. Please note that 40% of respondents in each sample have tried various computer games for the development of their own children. That is, they managed to direct the enthusiasm of modern children for gadgets and computer games in a useful direction, as well as to see from their own experience the possibility of using them for educational purposes.

Moreover, if to compare the answers of teachers at different levels of education (primary, secondary, senior secondary schools), all primary school teachers turned out to be supporters of computer games in the educational process. It is clear that this question needs to be investigated separately in the Ukrainian school, since the number of primary school teachers in our study was quite small for serious general conclusions. However, outside of Ukraine, studies conducted in primary schools regarding the use of educational computer games have shown good results in children's development (Perez et al. 2018).

In our research, together with those teachers who were already interested in computer mathematical games and tried their use, a significant percentage remained who doubted their effectiveness in the educational process. In particular, let us recall that in 2019 every third mathematics teacher expressed such an opinion and every fourth did not consider the possibility of their use in the study of mathematics at all (Table 3). The situation somewhat "softened" in 2021 and the number of those who paid attention to alternative digital learning technologies in the form of computer mathematical games increased. The number of teachers who were interested in them, used them in practice, and tried to play them themselves increased significantly (Tables 2 and 3).

At the same time, we remind that at least 60% of teachers (Figure 1) do not play

computer games (this group includes also those who play several times a year). In other words, unlike today's children, teachers (or the "adult population") do not immerse themselves in computer games and plan their leisure time outside of them. And if in the Figure 1 you can see a certain number of those who play them, then this may be the reason for the professional need. It is logical that the teachers should try out the new educational tool themself, figure out what the students will encounter, analyze which game, when and how to use it in a lesson, and be ready to suggest and help.

The aforementioned growing interest of Ukrainian mathematics teachers in computer games with the possibility of their use in the educational process is, in our opinion, caused by the COVID-19 pandemic. The forced transition to online learning of all educational institutions and the separation from the usual ("traditional") learning conditions forced teachers to search for and test digital technologies that were previously used by units.

The open answers of the respondents regarding the expediency of using computer mathematical games in the process of learning and teaching mathematics (the last question of the questionnaire) also changed their character somewhat. In 2019, the number of opinions expressed regarding the research question was insignificant and mostly negative in nature: "computer games will not help to learn mathematics", "learning of mathematics requires a serious approach", "I think that such games are better used in primary school or in the 5th grade". In 2021, there were significantly more open comments and positive notes have already appeared among them. In particular, teachers believed that computer games are appropriate in mathematics lessons, because they "are better perceived by students", "contribute to the development of critical thinking", "introduce variety into the educational process", they are "expedient to use in distance learning conditions".

In 2021, the statements of a negative nature were fundamentally different from the answers of 2019 because they contained explanations of the reasons for such an attitude of teachers. In particular, in their opinion, "computer games have a negative effect on vision and discipline". A similar position are expressed by Habgood et al., Preradovic et.al., Sayan. They pointed out that the constant use of computer games in the education of students, especially younger ones, can lead to a decrease in the level of knowledge, avoidance of live communication between students and other negative consequences (Habgood et al. 2011; Preradovic et al. 2016; Sayan 2015).

Some teachers mentioned "classroom management problems" caused by playing with gadgets in the classroom, and they stated that "classroom control can be lost". Heshmati et al. also noted that the interaction between the teacher and students in the learning process can be lost due to the use of some types of games. The latter can lead to a decrease in the level of students' knowledge of mathematics (Heshmati et al. 2018).

In addition, teachers noted that among the problems caused by the use of computer mathematical games in lessons, there are the following: "deviation from the goal of the lesson", "loss of the priority of mathematics", "students' perception of the lesson as only time for playing", "lack of proper methodical support". Based on the experience of online education, the issues of technical support were added to the questions of a purely didactic nature: "lack of the necessary technical infrastructure for using computer games". Moreover, a frequently mentioned problem was the provision of high-quality Internet connection, especially for residents of rural areas and small towns. The connection between the technical component and the very possibility of using computer mathematical games was clearly emphasized by the respondents who were searching for improvement of the online learning process. They encountered the fact that the found electronic games of an educational nature can only be played online. At the same time, under the conditions of a high-quality Internet connection, the possibility of using them both at home and at school looks attractive.

Of the games tested by teachers, which they use in their school practice, the most common were: "Treasury of knowledge","Mathematical puzzles QuickBrain" and "Smart Kids". It should be noted that the games listed above were noted by primary school teachers. These are games by Ukrainian developers that have a Ukrainian-language interface and are freely available. In particular, Smart Kids is recommended by the Ministry of Education and Science of Ukraine for teaching students of grades 1 – 4 of New Ukrainian School.As for secondary and senior secondary school teachers, the following answers were given: "Matific", "Kahoot", "Pythagorea".

Thus, against the background of growing practical interest of mathematics teachers in educational computer games, unsolved problems of their use also emerged. On the one hand, in 2021: 1) half of the respondents had a good opinion about the use of computer games in education; 2) almost 80% were sure of the benefit of their use for both the teacher and the student; 3) 71% of teachers wanted to know more information on this issue (Tables 2 and 3). On the other hand: 1) almost half of mathematics teachers still doubted that computer games could be considered as educational tools; 2) half of the respondents did not use computer mathematical games in their own working practice, although they had a good opinion about it; 3) approximately every second teacher in 2019 and every third teacher in 2021 noted that they were interested in computer mathematical games, but did not find anything worthwhile (Tables 2 and 3).

Therefore, let's talk about the fact that nowadays in Ukraine, the implementation of computer games into the process of teaching mathematics raises many controversial issues related to various aspects, in particular: setting goals, place and limits of the use of computer games in the educational process, the conscious selection of software products. Those teachers who use computer games in the process

of work face significant difficulties. Very often, from a large number of computer didactic games, a teacher cannot choose the ones that suit him/her and correspond to the specifics of the educational process of a particular school and group of students. In practice, programs may have a difficult interface for schoolchildren, others are overloaded with multimedia elements designed to use expensive computer system resources, and some simply do not meet the psychological and pedagogical requirements, and do not have a strict methodological basis.

Currentlythere is an urgent need to develop clear intended outcomes of learning using computer games that meet national curriculum standards. There is also a need to develop courses for teachers that would help master the basics of the concept of Game Based Learning, introduce various game interfaces and provide information about the principles and processes of learning based on computer games. Moreover, in 2019, our surveyed respondents (60%) considered in-service teacher training courses to be the main source of information. And although in 2021 this source still occupied the first position in the choice, the percentage of responses decreased (40%). After the quarantine, the demand for online resources has increased, both in the form of courses, trainings, and in the form of independent acquisition of knowledge. Please note that in-service teacher training courses are closely related to the Ministry of Education and Science of Ukraine and its education policy, and teachers, first of all, out of habit, could expect help from this side. But the accelerated demand for knowledge may not have matched the practical developments tested and approved at the highest level. This, in turn, contributed to teachers independently researching the issue of using computer mathematical games in the educational process.

The issue of using computer games in the educational process is currently gaining momentum. As an example, we will cite an innovation in the educational process of the Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University. In 2022 – 2023, a new elective discipline "Gamification in Education" was introduced in the cycle of general training at the Faculty of Mathematics, Physics and Computer Sciences. The new discipline was developed for future teachers of mathematics, informatics (computer science), physics and related to the issues of forming the skills of creating and using computer games in the future professional activity of a teacher. We assume that there are great prospects ahead for the systematic implementaion of computer mathematical games into the practice of Ukrainian school work.

5. Conclusions

In Ukraine, over the past three years, there have been significant changes in the views of mathematics teachers regarding the use of computer games in the learning process. In 2019, the majority of teachers (58% according to Table 3) did not consider it necessary to use electronic games in mathematics lessons: they doubted that

with the help of computer games it is possible to acquire the necessary knowledge and skills in mathematics, they were supporters of traditional education (without computer games) and were sure that using them in the educational process is just entertainment for students and a waste of learning time. In 2021, the number of teachers who held this opinion more than halved (about 22% according to Table 3).

A noticeable increase in the interest of teachers in computer mathematical games occurred after forced online learning in all schools of the state during the anti-epidemic measures in relation to COVID-19. Most of the respondents noted that the research question is timely and they have the desire and are ready to use computer games in their own work, but they emphasize the importance of considering the methodological aspects of implementation computer mathematical games into the practice of school work. In particular, mathematics teachers expect a clear explanation of what, where, how and when to do. In addition, most of them still hope to get answers to their questions on in-service teacher training courses, that is, in state educational institutions specially provided for the development of the professional culture of teachers.

In conclusion, we note that computer games are currently used sporadically in the process of teaching mathematics to secondary school students in Ukraine, since the vast majority of Ukrainian teachers are almost unfamiliar with the basic concepts of the concept of Game Based Learning. However, the growing interest of teachers together with their growing activity in finding answers to unsolved questions regarding the use of computer mathematical games in the educational process is gradually bringing Ukrainian education to world trends in this direction. Therefore, among the vectors of further theoretical development, we see the creation of appropriate methodological support for the involvement of foreign experience for the effective implementation of computer mathematical games in the processes of teaching and learning mathematics.

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