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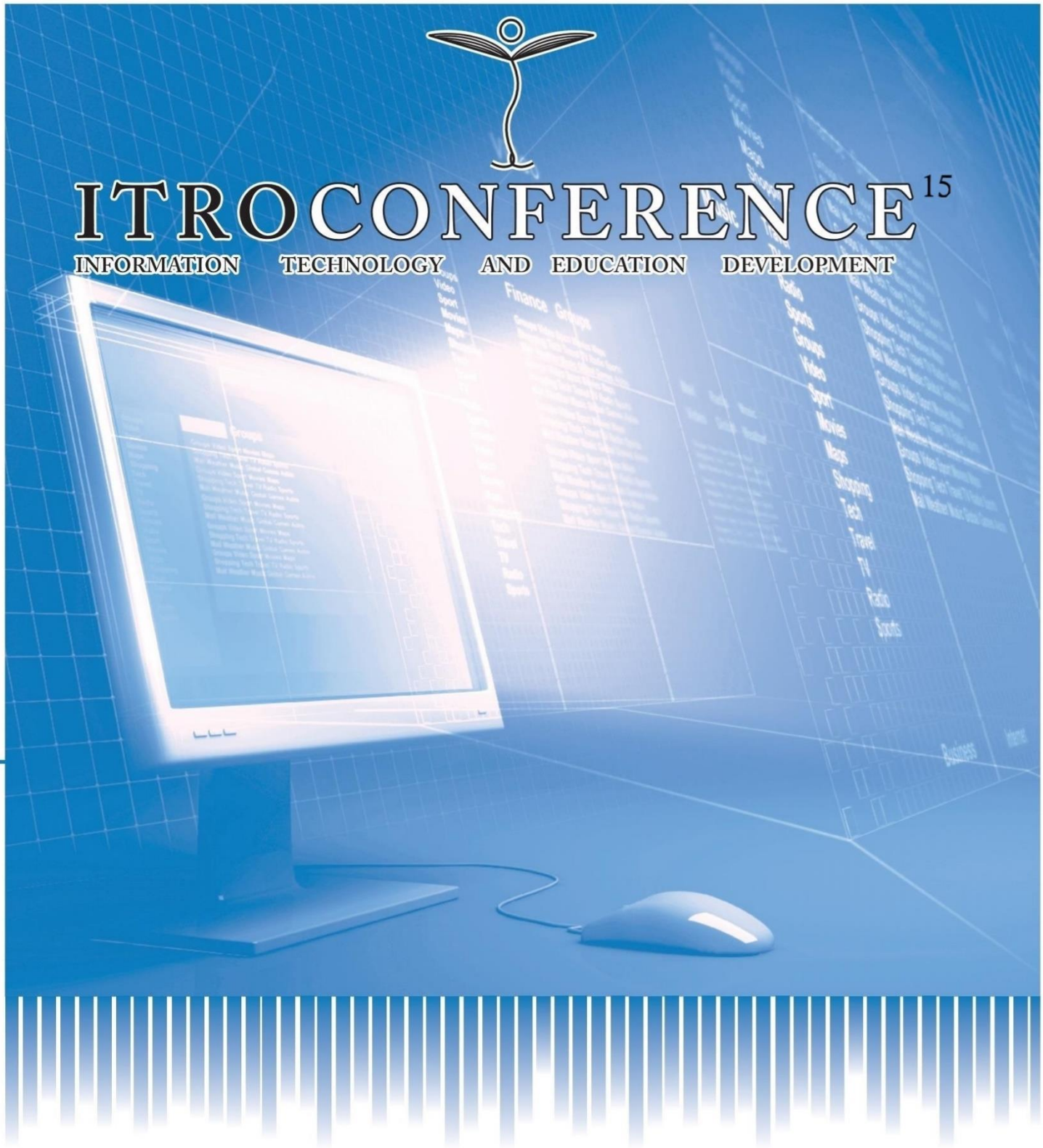
INFORMATION TECHNOLOGY AND EDUCATION DEVELOPMENT



PROCEEDINGS

ZRENJANIN, November 2024

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PLENARY PAPERS

SCIENTIFIC PAPERS

Enhancing Mathematics Education Through Digital Technologies and Innovative Approach

Jovevski D.*[1], Atanasova A.**[2], Pachemska T.A.*[3] and Peshevska Mitanovska A.*[4]

* GoceDelcev University, Stip, Republic of North Macedonia
** Ss. Cyril and Methodius University in Skopje, Faculty of Computer Science & Engineering, Republic of North Macedonia
[1]dobri.210197@student.ugd.edu.mk
[2]ana.atanasova@finki.ukim.mk
[3]tatjana.pacemska@ugd.edu.mk
[4]apesmit@gmail.com

Abstract. The digitalization of education represents a profound transformation in the manner in which teaching and learning are conducted, particularly with regard to the development of digital competencies and skills among teachers and students. The "Digital Skills for All" programs are designed to enhance the digital competencies of both students and teachers, thereby facilitating more effective utilization of information and communication technologies (ICT) within the educational process. The use of software tools that have been designed with the specific intention of supporting mathematics learning is becoming increasingly common. These tools provide approaches that facilitate interactive learning and problem-solving. These tools are distinguished by a didactic purpose, interactivity, and the capacity to adapt to the pace of the learner. The available evidence indicates that such approaches not only enhance students' interest but also facilitate a redefinition of the teacher's role, moving away from that of a mere lecturer towards a more active and facilitative role as a mediator of knowledge. It can be reasonably deduced that fostering critical thinking in students, solving logical problems based on analysis, motivating engagement in activities, and problem-solving contribute to the sustainable development of education. In this context, the present research aims to analyses the effectiveness of digital learning software, the success of students in using digital software depending on their academic level, the intensity of software use, the form and reason for using the software, and the impact of teachers' ICT competencies on achieving greater student success.

Keywords and phrases: digitalization, education, digital skills, competencies, mathematics

1 INTRODUCTION

In the contemporary era, new opportunities for dynamic life and contemporary education have emerged, necessitating the utilisation of digital resources and tools. The European Union's action plan for digital education (2021-2027) aims to facilitate the adaptation of education to the digital era, with a particular emphasis on ensuring inclusive and accessible education at all levels. This plan is an integral component of the vision for a digitally-enabled Europe, and it provides the foundation for the realization of the Digital Compass initiative up until the year 2030.

The Republic of North Macedonia is a member of the European educational community, and thus the participation in this initiative is of great consequence. The digital transition alters the manner in which digital educational content is utilized by teachers, students, and parents, who are becoming increasingly creative, interactive, and accessible in a multitude of formats. The advent of new technological achievements, such as virtual reality and artificial intelligence, has further augmented the production of digital educational content.

In the Republic of North Macedonia, there are several digital platforms that facilitate the provision of educational resources and tools. One notable example is the www.eucebnici.gov.mk digital library, which offers e-textbooks for primary and secondary education. Additionally, www.nastava,mk provides supplementary digital resources and tools to support the educational process. Nevertheless, there is a need for

further digitalization and digital transformation of textbooks, specifically the creation of interactive materials that will enhance the digital competence of students and teachers.

Concurrently, the outcomes of international assessments indicate a discrepancy between Macedonian mathematics textbooks and the European standards. This necessitates further endeavors to digitize and transform the teaching of mathematics and to provide teachers with the requisite support during this transition.

The objective of this study is to assess the efficacy of digital software, the impact of students' academic levels on their performance, the extent of software utilization, and the role of teachers' ICT competencies in enhancing student outcomes.

2 LITERATURE REVIEW ON THE USE OF DIGITAL TOOLS IN MATHEMATICS

The advent of digital tools has introduced novel avenues for interaction and comprehension of mathematical concepts. Students can engage in exploration and study through the use of games, simulations, and digital resources that facilitate the conceptual development process and provide valuable feedback. Such tools facilitate the visualization and comprehension of mathematical concepts, while affording educators the opportunity to elucidate and highlight details that may otherwise remain unnoticed (Hoyles, 2018). While these tools have been shown to have a significant impact on mathematical performance, their effect remains moderate (Drijvers, 2018).

The integration of traditional education with digital technologies facilitates enhanced support for independent study, thereby increasing students' success and fostering the development of independent thinking skills (Golding et al., 2021). The influence of intelligent tutoring systems and adaptive digital tools on student success has been demonstrated to be significant (Ma et al., 2014). However, these technologies are most effective when used in conjunction with traditional pedagogical methods, rather than as a replacement for them (Hillmayr et al., 2020).

The utilisation of digital tools in mathematics facilitates the creation of novel experiences for students, thereby fostering heightened interest and engagement (Wijaya et al., 2022).

3 METHODOLOGY OF RESEARCH

This research examines the efficacy of digital software in education, its impact on student success contingent on their academic level, intensity, and mode of utilization, as well as the role of information and communication technology (ICT) competencies of teachers. For students in fourth, fifth, and sixth grades, data regarding their academic performance and the extent to which they utilize digital tools is analyzed. For teachers, the level of their ICT competencies is evaluated through a survey comprising 23 indicators, as well as their impact on students' success.

The *objective of the research* is to examine the utilization of digital tools in mathematics instruction and to assess their impact on student achievement, with a particular emphasis on the role of teachers' information and communication technology (ICT) competencies.

The research is conducted through two databases: the Platform for Student Success and a survey for the evaluation of information and communication technology (ICT) competencies of teachers. Quantitative methods are used for data analysis, utilizing descriptive and conclusive statistics, including the F-test and chi-squared -tests. A total of 227 students and 43 teachers from diverse geographical and ethnic backgrounds participated in this research. Three exploratory hypotheses were formulated and subsequently evaluated. H1: The intensity of digital tool and platform usage is contingent upon the academic success and achievement of students in mathematics at the primary school level. H2. The manner in which students from primary school utilize digital tools and platforms for mathematical studies is contingent upon their academic success. H3. The level of success achieved by students in mathematics is significantly influenced by the extent of ICT competencies demonstrated by their mathematics teachers.

4 FINDINGS AND RESULTS

As previously indicated, the survey was completed by 227 students in grades four through six, as well as 43 mathematics educators who instruct students from diverse ethnic backgrounds in the eastern and western regions of the country and multiple educational institutions in Skopje. Of the students who participated in the survey, 114 (50.2%) were female and 113 (49.8%) were male.

Table 1 presents a description of students' success in mathematics in the last two school years. The arithmetic mean is significantly high at M=4.23 (SD=0.71), indicating a normal distribution of mathematics success among this group of students. In other words, the majority of this group of students, in addition to the arithmetic mean, also exhibit a lower proportional division at the edges of the curve, indicating a distribution of psychosocial phenomena.

Table 1. Descriptive statistics of students' success

		Students' Academic Succes
N	Valid	227
	Missing	0
Mean		4,2341
Median		4,3600
Mode		4,90
Std. Deviation		,71257
Minimum		2,27
Maximum		5,00

With regard to the shape and manner of utilization of the digital tools and the digital platform e-teaching in mathematics, the students have indicated their preferences according to the frequencies presented in Table 2.

Over 45% of students, primarily in the fifth grade, have indicated that they utilize the digital tools for a range of activities, including leisure and completing assignments assigned by the teacher. Forty-four percent of students, predominantly in the sixth grade, have stated that they employ digital tools as a substitute for traditional study methods. Additionally, 43% of students, primarily in the fifth grade, have reported using digital tools for both supplementary and recreational purposes.

Table 2. Form and intensity of use of digital tools and platforms in mathematics in primary education

			Class		
			Fourth	Fifth	Sixth
Form and way of using a digital tool in mathematics	I use it for studying as a supplement	Count	9	13	8
		Row N %	30,0%	43,3%	26,7%
	I use it for studying as a substitute	Count	8	6	11
		Row N %	32,0%	24,0%	44,0%
	I do my homework with it.	Count	16	13	18
		Row N %	34,0%	27,7%	38,3%
	I previously demonstrated my abilities and knowledge.	Count	18	13	17
		Row N %	37,5%	27,1%	35,4%
	I utilize it for recreational purposes.	Count	15	19	10
		Row N %	34,1%	43,2%	22,7%
	A little bit of everything	Count	9	15	9
		Row N %	27,3%	45,5%	27,3%
Intensity of use of digital tools and platforms in math classroom	I don't use	Count	13	18	12
		Row N %	30,2%	41,9%	27,9%
	Several times a month	Count	35	34	34
		Row N %	34,0%	33,0%	33,0%
	Two or three times a week	Count	17	18	16
		Row N %	33,3%	35,3%	31,4%
	Every day	Count	10	9	11
		Row N %	33,3%	30,0%	36,7%

In the second part of Table 2, a proportional division of the use of digital tools and digital platforms for e-teaching is observed according to the intensity of use. Notably, 42% of fifth-grade students have indicated that they do not utilize these tools, in contrast to the other students from the fourth and sixth grades. All other frequencies are proportionately distributed between 30% and 36%.

Conversely, data from the school's pedagogical service (based on an interview with one staff member) and data collected following the survey of teachers indicate that over 39% of these teachers have A significant proportion of teachers (37%) demonstrate a high level of ICT competencies for using and teaching through digital platforms in mathematics. However, a notable number of teachers (34%) exhibit a middle level of ICT competencies, while approximately 24% display a low level of ICT competencies for using and teaching through digital platforms in mathematics (Fig. 1).

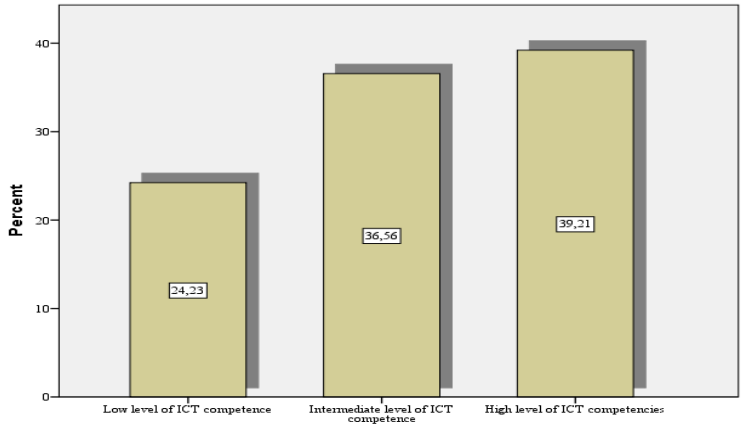

Figure 1. The level of ICT competencies of mathematics teachers in primary education

The data regarding the utilization of digital tools and platforms in mathematics among students reveals some definitive findings regarding the F-test. These findings indicate that the intensity of digital tool and platform usage is influenced by success and students' achievements in mathematics at the primary education level (represented by the first hypotenuse). Table 3 illustrates the mean success rates of students according to their reported frequency of digital tool and platform usage. The table also presents an F-test to assess potential differences between the two most frequently used categories (i.e., "Several times a month" and "Two or three times a week") and the least frequently used category (i.e., "I don't use").

Table 3. The academic success of students in mathematics and the intensity of use of digital tools and platforms in primary education

	N	*Mean*	*Std. Deviation*	*Std. Error*	*F*	*Sig.*
I don't use	43	4,1414	,78042	,11901	3,306	,021
Several times a month	103	4,3132	,58562	,05770		
Two or three times a week	51	4,0196	,82196	,11510		
Every day	30	4,4597	,73162	,13357		
Total	227	4,2341	,71257	,04729		

In accordance with the findings of the study, which yielded a value of F=3,306 with sig=.021 and a p-value less than 0.05, it can be concluded that there are notable differences between the levels in question. Consequently, it can be posited that the success of students in mathematics is contingent upon the extent to which they utilize digital tools and platforms in the context of primary education. In other words, the routine utilization of digital tools and platforms exerts a considerable impact on enhancing students' proficiency and comprehension of mathematics at the primary educational level. This is in contrast to students who do not employ such tools and platforms (Fig. 2). It can be concluded that the initial hypothesis is valid.

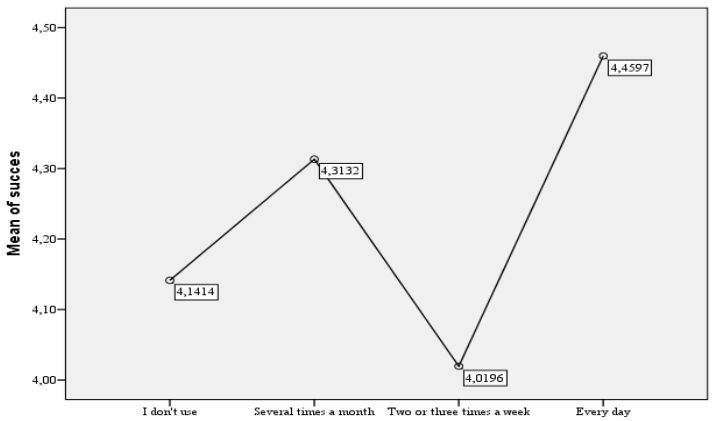

Figure 2. The success of students in mathematics and intensity of use of digital tools and platforms in primary education

However, an F-test analysis of the data presented in Table 4, which shows the mean success of students in mathematics according to the shape and manner of use of digital tools and platforms, yields an F-value of 1.078 with a significance level of .373 and a p-value greater than 0.05. This indicates that there is no statistically significant difference in students' success in mathematics at the primary education level based on the shape and manner of use of digital tools and platforms for studying mathematics. Based of these findings, we conclude that the second hypothesis that the shape and way of using digital tools and platforms for studying mathematics by students from primary education is determined by students' success itself, is not supported by the evidence.

Table 4. Students' academic success in mathematics and the form and reason for using digital tools and platforms in the subject of mathematics in primary education

	N	*Mean*	*Std. Deviation*	*Std. Error*	*F*	*Sig.*
I use it for studying as a supplement	30	4,1190	,63157	,11531	1,078	,373
I use it for studying as a substitute	25	4,4432	,71903	,14381		
I do my homework with it.	47	4,1213	,81656	,11911		
I previously demonstrated my abilities and knowledge.	48	4,2523	,61046	,08811		
I utilize it for recreational purposes.	44	4,1961	,72703	,10960		
A little bit of everything	33	4,3648	,73162	,12736		
	227	4,2341	,71257	,04729		

Following the processing of all data pertaining to students' success, as measured by the utilization of digital tools and platforms for the study of mathematics, four statistical levels have been identified with regard to the impact of digitalization on the teaching of mathematics. These are as follows: The level of difficulty in learning remains unchanged, with the same level of performance observed in the context of traditional teaching methods. However, there is a discernible improvement, both in terms of its magnitude and its significance. Subsequently, students were classified according to the aforementioned levels, and teachers were classified according to their level of ICT competencies. The results of this classification are presented in Table 5, made with chi-square test to analyze the significant differences between the frequencies.

Table 5. Influences (effect) of the teacher's ICT competencies to students learning mathematics

		The Effect in Students Learning			
		Difficult learning	Same level as before - with classical teaching	A small improvement	A significant improvement
ICT Competencies of the teachers	Low level of ICT competence	9	9	14	23
	Intermediate level of ICT competence	10	7	19	47
	High level of ICT competencies	11	13	20	45

As evidenced in Table 6, the chi-square quotients range from 15,133 with a significance level of .049 and a p-value less than .05. The crossing frequencies in Table 5 demonstrate significant differences, with higher numbers observed when crossing the last two levels (Intermediate and High levels of ICT competencies). This indicates a notable enhancement in mathematical learning among students, particularly among those who teach mathematics and possess advanced ICT competencies, and vice versa.

Table 6. Pearson Chi-Square Tests for crosstabs

		The Effect in Students Learning
ICT Competencies of the teachers	Chi-square	15,133
	Df	6
	Sig.	,049
Results are based on nonempty rows and columns in each inner most sub table.		

The results of this study support the third hypothesis, which posits that students achieve significantly greater success in mathematics depending on the high level of ICT competencies that their mathematics teachers possess.

5 Conclusion

This research is primarily concerned with the analysis of mathematics education in primary school settings, with a particular focus on the utilization of digital tools and resources in the classroom. It aims to investigate the efficacy of various digital software tools in the contemporary digital age, and to examine the factors that contribute to students' success in using digital software, including their academic level, the frequency and intensity of their software usage, the specific purposes for which they employ the software, and other relevant considerations. Furthermore, the impact of teachers' ICT competencies on enhanced student outcomes was investigated. Based on the findings, it can be concluded that the utilization of digital tools and digital platforms has a notable influence on the improvement of success and mathematics teaching among primary school students who employ them, in comparison to those who do not. It can be concluded that there is no significant difference in the success of students in primary school mathematics education based on the manner in which digital tools and platforms for studying mathematics are utilized. However, there is a notable improvement in students' mathematical abilities, particularly when their teachers possess a high level of ICT competencies, and vice versa. Therefore, it can be concluded that the objective of this research has been met.

In general, based on the theoretical findings and empirical analyses of this research, it can be concluded that the use of digital mathematics software has a positive influence on students' learning. Further opportunities for improvement exist, particularly in the design of study activities that integrate the software, the utilization of manuals for study relief and promotion of study through gaming. In conclusion, it is recommended that digital tools and platforms be reinforced and enhanced, and that additional educational software be developed, with the aim of facilitating more effective and efficient learning in the future. Furthermore, the implementation of techniques for disparate data analysis is recommended in order to predict academic performance based on a compilation of data from students.

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