

How to Improve the Mathematical Competences of Future Primary School Teachers in Ukraine? Innovative Aspect

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Abstract: The article attempts to optimize the development of mathematical competence in future primary school teachers via innovative technologies within the framework of the transitional form of Ukrainian higher education. The article aims to determine, substantiate and experimentally verify the effectiveness of organizational-pedagogical conditions for developing mathematical competence in future primary school teachers via innovative technologies. The study was an experiment and carried out during 2017-2020 and enrolled 648 students from faculties of training future primary school teachers (6 universities in Ukraine). For the successful carrying out of the study, theoretical, empirical (the main ones are molding and control experiments) methods, as well as methods of mathematical statistics to objectify the results of the experiment, were used. Previously, we have identified and described the organizationally necessary pedagogical conditions for successful development of mathematical competence in future primary school teachers via innovative technologies. In turn, we found a significant difference between the levels of students’ mathematical competence. The data obtained in the process of the molding experiment confirm the effectiveness of the author’s model and the specified pedagogical conditions for developing mathematical competence in future primary school teachers via innovative technologies, which bespeaks the achievement of the set goals of the work and the solution of the formulated tasks.

Keywords: *organizational and pedagogical conditions, mathematical competence, innovative technologies, Moodle environment, remote platform.*

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1. Introduction

A necessary condition for high-quality training of specialists is the compliance of education with the requirements of society. The basis for the modernization of modern higher education and the improvement of the vocational training process is the competence-based approach, which, first of all, provides for the formation of a competent specialist. The approval of the concept of the "New Ukrainian School" was the impetus for reforming the primary education system, in particular, the development of an updated State Standard for Primary General Secondary Education and curricula for grades 1-4 based on a competency-based approach is envisaged. Therefore, there was an urgent need to bring the process of training future teachers in line with today's demands. Achieving maximum results in this problem is possible with the use of innovative technologies that meet modern trends in the organization of the education system.

Considerable interest can be traced to the problem of developing mathematical competence in future primary school teachers. Relevant scientists are considering the development of a basic-methodological set in mathematics for all primary classes (Bohdanovych et al., 2008), development of students' cognitive activity in mathematics lessons based on the implementation of the polytechnic principle (Korol, 2000), the formation of skills of primary school students to solve text problems, methods of teaching arithmetic material to primary school students using multimedia technologies, creation of a pedagogical system of teacher training aimed at improving the efficiency of the process of forming students' ability to solve problems and improving their intellectual level (Skvortsova & Gaevets, 2013), development of mathematical culture of primary school teachers (Lodatko, 2012), formation of methodological and mathematical competence of future primary school teachers.

We analyzed the experience of foreign scientists, taking into account global trends in the formation of mathematical competence by means of innovative technologies. E-learning in higher education focuses on the work of Preston (2004). Electronic teaching and learning tools are justified in scientific developments (Bach, 2007; Cortada, 2012).

The content of the analyzed research indicates that currently there is an active introduction of innovative technologies in the training of a wide range of specialists. However, it should be noted that due to the need to introduce distance learning technologies, pedagogical science and practice requires a thorough scientific and theoretical research, experimental

development and testing of a model of developing mathematical competence in future primary school teachers via innovative technologies.

It has been established that in recent years, scientists have shown considerable interest in the training of future teachers, in particular, primary school teachers. Bondar (2008) focuses on the innovative training of primary school teachers, namely - on the competitiveness of graduates of pedagogical universities. Theoretical and methodological principles of primary school teacher training by means of innovative technologies are the subject of consideration by Strelets (2007). In order to deepen the knowledge of future teachers of primary education on modern educational innovations, the scientist proposes to introduce the course "Innovative pedagogical technologies in higher education." Modern scientists emphasize that teachers it is necessary to have innovative learning technologies and try to use them in professional activities. Their theoretical achievement is the coverage of innovative approaches to organizing the educational process, as well as the substantiation of a set of skills that determine the readiness of future teachers to innovative pedagogical activities (Bakhmat et al., 2019; Gerasymova et al., 2019; Maksymchuk et al., 2020; Melnyk et al., 2019; Nerubasska & Maksymchuk, 2020; Onishchuk et al., 2020; Sheremet et al., 2019). The search for ways to improve the process of developing future primary school teachers' mathematical competence is traced in the works of Trebyk (2015) (developed a set of computer tests in the Airen program for self-checking the readiness of college students to complete tests), Skvortsova & Gaevets (2013) (the effectiveness of the introduction of problem learning technology for mastering the educational area "Mathematics" is motivated, the expediency of forming the ability of students to solve plot problems has been proved).

There are several positions of scientists on the interpretation of the concept of "mathematical competence" that occur in the scientific community: "the ability to create mathematical models and apply the experience of mathematical activity" (Dakhin, 2002), "mathematical literacy and experience of independent mathematical activity" (Zinenko, 2009), "Acquisition of mathematical skills" (Rakov, 2005), "willingness to independently and responsibly apply mathematical tools" (Stelmakh, 2011). We used the corrected definition proposed in the Draft Higher Education Standard (manuscript) based on the understanding of scientific sources: mathematical competence - the ability to apply professionally oriented mathematical knowledge, skills and abilities in standard and non-standard situations.

The comparative analysis of the educational program for the preparation of a bachelor in the specialty "Primary education" (2006) and the

draft standard of higher education of Ukraine in the specialty "Primary education" (2016) (manuscript) showed a reorientation to the competence-based system of training a future primary school teacher. The Project thoroughly discloses the main components of subject competences, in particular, mathematical (arithmetic, logical, algebraic, geometric, identical transformations). In the structure of the criteria for considering mathematical competence, in addition to skills, knowledge, communication, autonomy and responsibility are determined. The Project clarifies the basic knowledge that the graduate must master.

Analysis of normative documents, study of the experience of domestic and foreign research allowed to identify key ideas for improving the process of forming the mathematical competence of the future primary school teacher in Ukraine: wide involvement of interactive technologies in the learning process; development and implementation of electronic publications, manuals, computer training systems, multimedia systems, electronic testing systems; creating a favourable information-oriented environment for learning; providing teachers with computer skills, involving teachers in mutual learning.

The content of the analyzed studies indicates that currently there is an active introduction of innovative technologies in the professional training of a wide range of specialists. However, it should be noted that due to the need to introduce distance learning technologies, pedagogical science and practice needs a thorough scientific and theoretical study, experimental development and testing of a model for developing mathematical competence in future primary school teachers via innovative technologies.

Relevance of the article. Thus, there is a need to resolve the contradictions between: the need for the introduction of distance learning technologies in connection with modern requirements and insufficient theoretical and methodological development of innovative technologies; the need to develop mathematical competence in future primary school teachers via innovative technologies and the lack of science and practice of a specially developed model and organizational-pedagogical conditions for developing mathematical competence in future primary school teachers via innovative technologies.

Thus, a detailed study of the problem in question revealed a number of unsolved problems: to strengthen the practical orientation of higher education, to update educational standards, in particular, the structure and content of teacher training, requirements for graduates of "Primary Education" in the form of a list of competencies; bring in accordance with the license conditions the availability of electronic resources of the

educational institution, which must contain appropriate educational and methodological materials; install free software for distance learning in universities; to compile sets of innovative instructional and methodical materials based on relevant Internet resources.

Therefore, promising areas of further research are the development and implementation of the author's model for developing mathematical competence in future primary school teachers via innovative technologies in the educational process.

Purpose of the article. Since it is impossible to resolve all the above contradictions within the framework of the article, we set a partial goal: to determine, substantiate and experimentally test the effectiveness of the organizational-pedagogical conditions for developing mathematical competence in future primary school teachers via innovative technologies in the Ukrainian educational space.

2. Research methods:

- theoretical: analysis of psychological and pedagogical literature, work experience of scientific and pedagogical workers of higher educational institutions in Ukraine and abroad; analysis, synthesis, induction, deduction, systematization, classification - for the systematization of relevant materials on the problem in question;

- empirical: observation, conversation, study of the results of students' activities; ascertaining, molding, control experiments to verify the effectiveness of using innovative teaching aids;

- methods of mathematical statistics used to process the data obtained, quantitative and qualitative analysis, obtaining the scientific reliability of the results

Filling with data was carried out by testing knowledge within the framework of the academic discipline "Mathematics" during the experiment (its initial and final stages) (performing algebraic, geometric and logical tasks using innovative (computer) technologies). Verbal data were obtained through a questionnaire survey in order to study the feasibility of improving the process of forming mathematical competence from the student's point of view.

Research ethics. The experiment was coordinated with the ethics committees of the universities, where the following studies were carried out. The participants themselves gave voluntary consent to participate in the experiment without negative consequences for them.

3. Literature review

We have critically worked out the English-language scientific research concerning the problem of the implementation of the competence-based approach in specialist training in HEIs. We found that the competence approach in vocational education involves the acquisition of knowledge and skills by students in the context of direct professional activity. Preston (2004) notes that the purpose of education is to train a competent primary school teacher. Cortada (2012) reveals the peculiarities of attracting innovative technologies into the learning process in UK universities, emphasizing the need to use innovative methods and new flexible methods. The peculiarities of the development of distance education in Great Britain are also devoted to the work "Online Learning and Teaching in Higher Education" by Bach et al. (2007) in which the authors note that the main feature of distance education in higher pedagogical education is the creation of educational environment.

However, we offer an overview of the more recent sources available in the international scientific and methodological discourse.

One of the problems of teaching mathematics in elementary school is the motivation of the educational activity of a child who does not have such developed abstract thinking. In addition, today's digital children are very sensitive to innovation (sometimes more than the teacher himself). Therefore, as scientists note, a future teacher needs to record innovative trends, which will quickly build a common developmental environment for teacher and student (Samusevica & Striguna, 2017).

Recently, in post-socialist countries, a lot of experimental studies have been carried out on the effectiveness of the formation of professionalism of future mathematics teachers using multimedia technologies. Such studies aim to develop and test partial (author's) technologies for developing professionalism in future mathematics teachers (Gluzman et al., 2018). The generality of their results is that the effectiveness of these technologies will be ensured with the integrity and interdisciplinary of the pedagogical process, a clear definition of the educational line (with variable deviations), modernization of software and methodological support and a reasonable combination of traditional and multimedia means.

In classical Western studies, the pedagogy of elementary school, as a rule, is contrasted with humanitarian subjects with natural and mathematical ones. Therefore, there is a problem within the framework of the integrative nature of education in the era of globalization: how to make mathematics humanitarian. The role of the primary school teacher in the humanization of

the individual is decisive, since in most countries the primary school teacher teaches all the basic subjects. Currently, scientists offer the so-called STEM education, which is used to the maximum in a globalized environment. The first experimental studies have already been carried out among elementary school teachers, mathematics and science. The results are encouraging: teachers' awareness of the innovative perspectives of STEM education exceeds conservative positions (Bakirci & Karisan, 2018). For Ukrainian teachers, such prospects are still unattainable due to the traditional approach, but within the framework of the recently introduced New Ukrainian School (NUS), the skills of "being ready for a complex world environment, making difficult decisions and possessing critical thinking skills related to problems everyday life" (Bakirci & Karisan, 2018, p. 32).

Against the background of the need to modernize the mathematical education of primary schoolchildren, the issue of teaching aids is acute. The ratio of virtual (electronic, multimedia) tools and classical textbooks is especially important. The results of multilevel regression analysis on the impact of different textbooks on primary school students' mathematical performance have proved that the textbook is still the most important tool for its variability and appropriate choice by the teacher (van den Ham & Heinze, 2018). For our research, this means an unambiguous postulate: the future teacher should not ignore the proven means for centuries and rely only on innovative means, which will be observed in our research.

The scientometric bases of the latest research in the field of higher education methodology and teacher training for primary grades and mathematics offer an extremely segmented research subject. Among teachers, there is still debate about the discreteness of the so-called "school mathematics", "mathematics for mathematicians" and the connection between mathematics and life (the latter is often doubted by students) (Beswick, 2012). A specific problem is the assessment of mathematical knowledge in the lower grades: should a future teacher be guided only by quantitative indicators or should he take into account irrational educational indicators? (Brown & Hirschfeld 2007; Tamba et al., 2021). An important issue is the nature and actual practice of teacher-student feedback and the reflection of subjects of education in mathematics lessons, the result of which should be rationalized indicators (Dixon & Haigh 2009). At the same time, STEAM education, permeated with ICT, has become a breakthrough in international scientific and practical education. "This has made widespread use of information technology, which has a profound impact on mathematics education" (Wijaya et al., 2020).

The arsenal of methods, approaches and technologies for training primary school teachers for teaching mathematics is extremely wide, but it is still a subject of discussion. The ideas analyzed above will only be partially taken into account when planning and conducting an experiment, since the Ukrainian educational space is only acquiring features of the Western European one, and we must take into account the unchanging realities so far.

4. Materials & methods

In order to improve the development of mathematical competence in future primary school teachers, we have developed and substantiated an experimental model of developing such competence via innovative technologies.

Taking into account the social order and the specific goal of experimental activity, the main tasks are outlined, consisting in educational and methodical support to improve the development of mathematical competence in future primary school teachers.

We have identified and described the organizationally necessary pedagogical conditions for successful development of mathematical competence in future primary school teachers via innovative technologies. The first condition is the innovative potential of the educational institution in terms of perceiving, creating and implementing innovations in the educational process and in time to get rid of the outdated, pedagogically inexpedient. For example, the registration of Taras Shevchenko National Pedagogical University in Chernihiv in the Moodle environment on the electronic remote platform is focused perspective on expanding the possibilities of improving the process of developing mathematical competence in future teachers. A necessary condition for effective development of mathematical competence in future primary school teachers is the creation of an innovative environment that provides pedagogically appropriate organization of the educational space and the realization of the innovative potential of the educational institution. The essential condition for creating an innovative environment is the development and implementation of electronic methodological complexes.

Another important condition for the effective formation of mathematical competence is the innovative potential of the teacher, ie a set of personal, sociocultural and creative features of teacher's personality, which lie in his or her willingness to enhance teaching activity, including the acquisition of skills with electronic methodological complexes.

The development of the author's model is based on the following principles: scientific (embodied in curricula and manuals, in the selection of material studied, as well as in the fact that students master the elements of scientific research); systematic (constant comprehensive work on improving knowledge, skills, abilities and the formation of competencies; the introduction of innovative technologies in all components of the process of forming mathematical competence); accessibility (submission of information at an accessible level; development of methodological materials aimed at facilitating the process of perception); consciousness (conscious assimilation of knowledge for further practical use); organic unity of theoretical and practical training (orientation of theoretical training on practical activity and future professional activity).

An important component of the model is the content-activity component, which covers theoretical and practical work aimed at developing mathematical competence in future primary school teachers. Forms and means of such activity are singled out, in particular, attention is focused on the developed educational and methodical materials: multimedia presentations, educational and methodical manual "Methods of teaching the educational field" Mathematics ", textbook "Fundamentals of work in the environment Moodle ", electronic methodical complex branch "Mathematics", developed in the Moodle environment.

A special role in the developed model belongs to the course "Fundamentals of work in the environment", which aims to provide skills in creating and configuring e-courses and recommendations for their application in practice. The course covers the most relevant aspects of working with the Model environment, as well as the creation of sets of digital methodical materials within the practical classes.

Before the start of the experimental work, the criteria for developing future primary school teachers' mathematical competence were determined: positive motivation for professional mathematical activity (motivation for professional self-improvement in terms of mathematical competence formation; interest in theoretical principles of mathematics and application of acquired knowledge in professional activity; mathematical competence in students), possession of methodical apparatus and skills to organize the educational process based on innovative technologies in primary school (completeness of theoretical knowledge and practical skills in mathematics and its teaching methods; systematic knowledge of mathematics and its teaching methods in primary school; possession of practical skills mathematical knowledge in practice) and student self-awareness (adequate

level of self-esteem; individual teaching style based on advanced methods of teaching mathematics in primary school).

To verify the effectiveness of the proposed experimental model, a pedagogical experiment was conducted. The study was conducted during 2017-2020 and covered 648 students of pedagogical faculties from six HEIs in Ukraine.

The main stages of the pedagogical experiment, their purpose and features are determined. The stages of the pedagogical experiment included ascertaining and forming ones.

In the process of ascertaining experiment the existing conditions and features of developing mathematical competence in future primary school teachers are investigated. After analyzing both theoretical and methodical state of forming mathematical training in future primary school teachers in higher education, they found that the traditional system of professional training, focused on acquiring knowledge, skills and abilities in a particular field, does not meet public demands. Therefore, there is a need to implement and experimentally verify the effectiveness of the author's model of developing mathematical competence in future primary school teachers via innovative technologies. The formative stage of the experiment consisted in introducing innovative teaching aids in the educational process. Within the framework of the experiment, the developed educational and methodical support was involved: a set of multimedia presentations, educational and methodical manual "Methods of teaching the educational field" Mathematics ", textbook" Fundamentals of work in the environment "and electronic methodical complex" Methods of teaching educational field "Mathematics". developed in the Moodle environment.

Experimental training covered 1st year students (subject "Mathematics"), 2-3 courses (subject "Methods of teaching the educational field" Mathematics "), 5th year (subject" Technologies of teaching mathematics ") and graduate students (subject" Mathematics "). Methods of teaching the professional discipline of primary education in higher education: "Methods of teaching the educational field" Mathematics ").

In order to clarify the state of formation of mathematical competence among students within the discipline "Mathematics" a section of knowledge was conducted. The tasks contained arithmetic, algebraic, geometric material, were aimed at implementing identical transformations and the development of logic. In addition to a slice of knowledge aimed at directly revealing the level of formation of mathematical competence in students, in order to study the appropriateness of improving the process of formation of mathematical competence through the introduction of

innovative technologies, we conducted a survey among full-time and part-time students. The tasks and questionnaires offered to students were developed by the authors.

The reliability of the obtained results was also verified by the methods of mathematical statistics. At the ascertaining stage, the levels mathematical competence in students in the control and experimental groups was checked using the criterion χ^2 (xi-square). In order to determine the statistical homogeneity of the studied groups, the software tool Gran1 was used.

5. Results

According to the results of this study, it was found that the level of this characteristic in students of both groups is statistically the same and allows to involve them in experimental activities (Table 1).

Table 1. Definition of statistics of criterion χ^2 (xi-square) on the distribution of students following the levels of mathematical competence at the ascertaining stage of the experiment

Sample	Low level	Medium level	Sufficient level	High level	Sample size N	Criterion statistics $T_{observ.}$
Control group	33	54	193	21	301	7,07
Experimental group	40	80	202	25	347	

Source: Authors' own conception

At the stage of formative research, a repeated study of mathematical competence levels in the control and experimental groups was carried out. It was found that EG students showed significantly better results than CG students, which indicates the effectiveness of using innovative technologies in the development of mathematical competence (Tables 2, 3).

Table 2. Determining the statistics of the criterion χ^2 (xi-square) from the distribution of students following the levels of mathematical competence at the end of the formative stage of the experiment

Sample	Low level	Medium level	Sufficient level	High level	Sample size N	Criterion statistics $T_{\text{observ.}}$
Control group	58	78	84	81	301	
Experimental group	21	65	130	131	347	64,9

Source: Authors' own conception

Table 3. The results of formation of mathematical competence of the future teacher of initial classes by means of innovative technologies are generalized

Levels of formation of mathematical competence	Ascertaining experiment				Forming experiment			
	Control group		Experimental group		Control group		Experimental group	
	number of people	%	number of people	%	number of people	%	number of people	%
Low	33	11	40	12	58	19	21	6
Medium	54	18	80	23	78	26	65	19
Sufficient	193	64	202	58	84	28	130	37
High	21	7	25	7	81	27	131	38

Source: Authors' own conception

Data interpretation. According to the results of the formative experiment, a low level of formation of mathematical competence was found in 6% of students in the experimental group, an average level - 19%, a sufficient level - 37%, a high level - 38%. The statistical processing of the obtained results indicates a positive trend in mathematical competence levels after the use of innovative technologies. There was a significant difference between the levels of mathematical competence in the control and experimental groups: in the CG the high level was 7%, in the EG - 38%.

The data obtained in the process of the formative experiment confirm the effectiveness of the author's model and specified pedagogical conditions for developing mathematical competence in future primary school teachers via innovative technologies, which indicates the achievement of the goal and solving the formulated tasks. The experts who checked the proposed teaching materials provided positive feedback, confirming the relevance of their use in HEIs.

6. Discussion

The scientific value of the obtained results is as follows:

– for the first time the efficiency of the author's model of developing mathematical competence in future primary school teachers via innovative technologies is developed and experimentally checked; defined, theoretically substantiated, concretized and experimentally tested organizational and pedagogical conditions for developing mathematical competence in future primary school teachers, the implementation of which allows to organize the educational process. The organizational and pedagogical conditions include the innovative potential of the institution (registration of the institution on the electronic platform Moodle), innovative environment (development and implementation of electronic methodological complexes created in the Moodle environment), innovative pedagogical activities of students and teachers (acquisition of skills with electronic methodological complexes);

– the content and structure of future primary school teachers' mathematical competence are investigated, the essential possibilities of its formation by means of innovative technologies are revealed;

– the levels, criteria and indicators of mathematical competence levels in future primary school teachers of are proved;

– the criteria of selection of means of innovative technologies for maintenance of developing mathematical competence in future primary school teachers are defined;

– research of innovative forms, methods and tools of developing mathematical competence in future primary school teachers was further developed.

The practical value of the obtained results lies in elaborating and introducing in professional training of future primary school teachers the textbook "Fundamentals of work in the Moodle environment", which helps to master theoretical knowledge and practical skills with electronic methodological complexes in the Moodle environment. Given the urgent need to train future teachers to use distance learning tools, the curriculum for bachelors in 6.010102 "Primary Education" introduced the discipline of free choice (cycle of professional and practical training) "Fundamentals of work in Moodle", and some topics from the course are included in the discipline "Innovative pedagogical technologies in higher education" for students majoring in 8.010102 "Primary Education".

Developed and successfully implemented in the educational process educational and methodological support for developing mathematical competence in future primary school teachers, which includes: teaching

manual "Methods of teaching the educational field of Mathematics" and electronic methodological complex created in the Moodle environment for students majoring in 6.010102 "Primary Education".

Educational and methodical materials prepared by the authors provide an opportunity to use the provisions and conclusions in order to improve the educational process in higher education, in particular in the development of mathematical competence in future primary school teachers during practical classes and within their self-education.

7. Conclusions

It is revealed that modern tendencies of development of domestic and world pedagogy, modernization and innovation of higher education allow to use means of innovative technologies and the competence approach as a methodical basis for the decision of a problem of mathematical competence development. This is also evidenced by the analyzed regulations in the field of education, work of domestic and foreign scientists. The analysis allows us to state that despite the considerable attention to the issue of improving the educational process there is a need to create electronic methodological complexes based on the Internet resource, bringing their availability in line with licensing requirements.

To ensure the effective implementation of the system for developing mathematical competence via innovative technologies, we have identified and substantiated the basic organizational and pedagogical conditions that meet the requirements of modern education and are based on the principles of scientific character, consistency, accessibility, consciousness, organic unity of theoretical and practical training: the innovative potential of an educational institution (registration educational institution on the electronic Moodle platform), an innovative environment (the presence of electronic methodological complexes), innovative pedagogical activities of students and teachers (the acquisition of skills in the Moodle environment).

We have developed and implemented the author's model of developing mathematical competence in future primary school teachers via innovative technologies has been developed and implemented, which includes value-target, content-activity and control-reflexive components. The effective formation of the mathematical competence of the future primary school teacher was facilitated by the introduction of the author's discipline "Basics of work in the Moodle environment", aimed at acquiring the skills of working with electronic methodological courses of future teachers.

Owing to the experiment, the effectiveness of attracting innovative teaching aids in the development of mathematical competence in future primary school teachers was confirmed, which do not change the traditional system of training a competent specialist, these teaching aids are an integral part of this process. The results of the experiment demonstrated that the use of innovative technologies can significantly improve the process of forming the mathematical competence of future primary school teachers, while maintaining the main educational content, introducing innovative means of presenting it, providing a targeted complex effect on the acquisition of mathematical knowledge and the formation of practical skills.

Therefore, the importance of introducing organizational-pedagogical conditions and means of innovative technologies in the development of mathematical competence in future primary school teachers is confirmed by experimental work. Experimental verification also confirmed the effectiveness of the model proposed in the work.

Study limitation. The study does not cover all aspects related to the use of innovative technologies for developing mathematical competence in future primary school teachers. The following issues need further elaboration: expansion of the system of electronic resources of higher educational institutions, involvement of a wide range of pedagogical community (scientists and teachers-practitioners of primary education) to work in the conditions of using free software.

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