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Pedagogical Readiness of Mathematics Teachers to Implement Innovative Forms of Educational Activities

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ABSTRACT

The purpose of this study is to develop and validate the evaluation indicators of teaching. The relevance of the present study is due to the problem of improving the quality of school education in the Russian Federation by means of renewal of the content of general education, provided by the RF State program "Development of Education for 2013-2020". The vectors of updating are determined by the tasks of transition to the democratic and constitutional state, the market economy, the need to overcome the dangers of the country lagging behind global trends of economic and social development and, what is the most important, by the growing influence of the human capital on the economy of the country. The aim of this study is to identify the level of readiness of teachers to implement innovative forms of educational activities into the educational process with the help of the analysis of the responses of mathematics teachers to reflexive questions. The presentation of lessons with innovative forms during the methodical workshop and the systematic analysis of the experimental data are the main technologies. As a result of the experimental study, conducted in 2015-2017 in the Kirov region with a group of 71 mathematics teachers we can present the experience of the implementation of innovative organization forms of educational process and summarize the results in the form of the subjective reflective assessment. The article justifies the high level of pedagogical readiness of mathematics teachers to introduce innovative forms of organization of educational activities such as: event-based learning, adaptive teaching, 'bring your own devices', computational thinking, and stealth assessment.

Keywords: forms of organization of learning activities, pedagogical innovations, advanced pedagogical experience, a creative lesson, TRIZ pedagogy

INTRODUCTION

After the adoption of the state program of the Russian Federation "Development of Education for 2013-2020" there has begun the updating of the content of general and professional education. The vectors of updating are determined by the tasks of the transition to the democratic and constitutional state, the market economy, the need to overcome the dangers of the country lagging behind global trends of economic and social development and, what is the most important, the growing influence of human capital on the economy of the country (the Government of the Russian Federation, 2014). Most of the innovations in teaching activities are related to the implementation of the Federal State Educational Standards in general education and professional education. The

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Contribution of this paper to the literature

- The article proposes to use generalized innovative forms of organizing educational activities on the subject, which may become a support to define strategies of pedagogical innovations in the practical work of educational institutions and teachers.
- For the first time the problems of teachers' pedagogical readiness to implement new forms of teaching are discussed that allow us to establish the priority of teachers' preparation to the implementation of the innovation, but not the process of innovation itself.
- While selecting new forms of teaching, it is possible to consider innovative practices unusual for teaching of mathematics, as well as the practices used for a wide range of various school subjects.

Federal State Educational Standard has becomes a reference point for understanding the new curriculum. On the other hand, the new interests and needs of the younger generation cannot be satisfied with updating the educational content, they depend on the forms of learning activities. Traditional forms prevailing in teaching in educational institutions no longer meet the expectations of students, they are the people who soon will have to make their own responsible decisions and think of the possible consequences, to be able to cooperate, to be mobile, dynamic and constructive. It is necessary to analyze hoe children understand the school of the future (Official Microsoft channel in Russia, 2015). Therefore, there should be the renewal of education and educational content with the help of new forms of learning with a reference to the international practice.

Innovative Forms of Organization of Learning Activities

Traditionally, pedagogical innovations in Russian education are summarized after the successful implementation of the activities in educational institutions. In the world educational space there is a different approach – a prognostic analysis of possible innovations in education in the future. This analysis allows to work out and introduce the innovations in the educational experience of educational institutions. The most important and well-known analyzes of the possible innovations in education in the future are presented in the reports of scientists from the UK Open University (Open University, UK, 2015) and the European Commission for Education and Culture (European Commission on Education and Culture, 2014). These reports helped us to outline the main and most acceptable forms of organization of educational activity of students to the Russian education system, such as open social learning, flipped classroom, bring your own devices, event-based learning, crossover learning, bricolage, computational thinking, adaptive teaching, stealth assessment (Horizon Report Europe, 2014). They are briefly described below.

1) Open social learning – the development of the idea of using the open online courses and video lectures in organizing communities for peer-learning network. Possible ideas for implementation: short-time discussion groups on the subject; the use of online learning effect; connection with social-networking; virtual worlds to develop the project; rating discussion comments of students and so on (Yarullin et al., 2016).
2) Flipped classrooms – the class becomes a space for dynamic, interactive learning, where the teacher helps the students to apply the knowledge that they have learned at home. Possible ideas for implementation – the developing and testing a series of classes on the subject, where the theoretical part of the program is studied at home, home assignments and exercises are analyzed in the classroom in detail.
3) Bring your own devices – when pupils bring their own smartphones, laptops, tablets and other devices in the classroom it can change their relationship with the teacher. Possible ideas for implementation – the development and testing a series of lessons on the subject where students use their personal devices.
4) Event-based learning – schoolchildren learn with a great desire during educational festivals and celebrations: maker fairs; cultural festivals, art and history festivals; conferences; regional events. Possible ideas for implementation: a system of subject events; a system of educational events and meetings.
5) Crossover learning – informal learning, such as museums and after-school clubs. Unlike learning in schools, it links educational content and things that matter to learners in their live and enriches experiences. Possible ideas for implementation: discussion issues that are topical for students, followed by the search for answers outside the educational organization; borrowing everyday activities (visiting museums, trips and so on), taking photos as the proof (Kiryakova et al., 2016).
6) Bricolage – working creatively with any tools and resources. It was originally used in relation to practical activities, such as carpentry, later – to any items for training, except for specially created. The simplest example of bricolage can be the experiments in chemistry classes. Possible ideas for implementation: the development of lessons with the use of non-traditional subjects; development of lessons with the use of unconventional resources.

7) Computational thinking – a special approach to thinking when problem solving. It involves five steps: breaking large problems down into smaller ones (decomposition), recognizing how they relate to problems that have been solved in the past (pattern recognition), setting aside unimportant details (abstraction), identifying and developing the steps that will be necessary to reach a solution (algorithms) and refining these steps (debugging). Possible ideas for implementation – not to encourage students to act on algorithms, and to teach them the standards of thinking, follow the five steps of the thinking.
8) Adaptive teaching – using the data about a student's previous learning and the data about the current learning to create a personalized path through educational content
9) Stealth assessment. Automatic data collection continues in the background when the students work with electronic digital resources, and it can provide a discreet, "tricky" assessment of their learning. Possible ideas for implementation: diagnosis of "non-educational" outcomes; the system of dual estimation (the result + the change); method of "pre-intervention"; educational outcomes assessment scale based on existing ones (nation-wide verification work, OGE, GVE, USE).

Literature Review

Pedagogical innovations in global mathematical education are considered recently most actively. Scientists Demirel and Turan (2010) analyzed the educational effects of problem-based learning introduction and came to the conclusion about the need for student to understand assigned problems and the ways of their effective solutions. For this understanding, the developmental math problems and their following reflective discussion may be offered (Gorev et al., 2017). In their work, Lamanauskas and Augienė (2015) suggest introducing such forms of educational activities that aim at the development of scientific research in a secondary school, which enhances analytical thinking of students, form the capabilities to find and to use information. Intensification of analytical thinking is possible through the introduction of universal and experimental learning, which scientists Chiou et al. (2017) consider as pedagogical innovation. Abrahams and Reiss (2012) in their works show that practical work is more effective if it avoids the use of explicit strategies for solutions and takes more practice-oriented approaches. Ding et al. (2007) studies the forms of educational activities organization aimed at joint balanced use of classmates' resources, the so-called cooperative learning.

The other innovations can be found in e-learning practice (Liu, 2016). So, Alias et al. (2013) consider web quests as a source of student's learning styles detecting that were implemented by scientists in pedagogical module for teaching physics. Su and Cheng (2015) consider the motivational game and mobile learning in general as a practice of e-learning. In general, e-learning practices can be considered as a form of knowledge management (Wu et al., 2016). For this set of practices, we can identify the issues impeding e-learning implementation (Pelgrum, 2001).

Erath and Prediger (2014) in their study show mathematical practices as under-defined learning objectives. So, much attention among pedagogical innovations in the literature is given to flipped classroom (Limniou et al., 2017). Ng (2015) sees flipped classroom as a point of digital technologies integration into teaching process. On the other hand, flipped classroom can be a form of mobile learning development and become a source of self-regulated learning (Hwang et al., 2015; Wang, 2016). Flipped class as an innovation is considered for use in higher education institutions (Aronson and Arfstrom, 2013). In the flipped class, they successfully implement the training using case studies (Herreid and Schiller, 2013) or training via web courses (Baker, 2000).

MATERIALS AND METHODS

The Research Methods

A complex of different methods has been employed: the study of regulatory documents, theoretical analysis of the pedagogical and psychological literature; analysis of learning products, method of mental experiment, forecasting; synthesizing of facts and concepts, modeling, instructional design, reflective assessment method, analysis of the learning activities results, study and generalization of the experience of application of innovative forms of organization of learning activity, pedagogical experiment.

Experimental Base of the Study

The experimental work was conducted by means of demonstration the innovative forms of the lesson to teachers. We presented these innovations from the perspective of the organization of innovative activity of educational organization and the possibility of their implementation in the educational space of Russian educational institutions in the course of the methodological seminar "The positive experience of the innovation in teaching mathematics at school". This seminar was held for teachers of mathematics of the Kirov region. The participants (more than 70 teachers of mathematics of Kirov and the Kirov region of various ages) were presented

reports, master classes and open lesson with the use of the innovative forms of lessons. It should be noted that 71 teachers voluntarily participated in our reflexive survey.

Stages of the study

The study was conducted in four stages:

1) The first (preparatory) stage was devoted to the analysis of the current state of the investigated problem in pedagogical theory and practice, at this stage the innovative educational organization of the educational process were defined.
2) The second (main, applied) stage was to develop the innovative educational organization of the educational process at math lessons in schools providing general education. The verification of the methodology effectiveness for experimental work was carried out.
3) The third (main, demonstration) stage was aimed at demonstration of the effective innovative forms of School Organization and Management. The experimental work on the analysis of mathematics teachers' pedagogical readiness to their implementation was conducted.
4) In the fourth stage series of lessons based on best practices were developed and tested. Positive practices have been adapted for teaching in classes by two experimental groups. The first group of teachers with motivational readiness to implement positive practices. The second group of teachers with the lack of motivational readiness for implementation of positive practice
5) In the fifth (final) stage systematization, interpretation and synthesis of the research results, refinement of the theoretical conclusions, processing and registration of the obtained results were carried out.

RESULTS

Key Demonstration of the Innovative Forms during the Methodological Workshop

In the report "Innovative pedagogical experience in global education" an overview of innovations in education and possible modern forms of organization of educational activities of students were provided (Utemov, 2016; Asadullin et al., 2016).

The presentation "The creative lesson of Mathematics as a means of improving the quality of education" represented the experience of using open type tasks on the creative lesson on Mathematics in NFTM-TRIZ System (Gorev and Rychkova, 2015).

The report "Event-based learning in the context of the innovative activity of educational institutions" was devoted to the presentation of the event-based learning in the context of educational innovative activities in MOAU "Lyceum № 21" Kirov (Gorev, 2015).

The workshop suggested two master classes and one open class, which show new forms and approaches to teaching students Mathematics.

The master classes "The technology "flipped classroom" in the practice of teaching mathematics" and "TRIZ tools on a Mathematics lesson, or from trials and errors to system thinking" were presented. Rychkovav (2015), the winner of the contest "Teacher of the Year of Russia - 2016", showed an open lesson in the 8th class on the theme "Square of shapes", where she used the bricolage and the bring-your own devices methods (Sharples and Adams, 2015).

Reflective Analysis of the Workshop

The event ended with a reflective analysis of the seminar. The participants were asked to evaluate the presented innovations by answering three questions.

Reflective question №1. Evaluate the possibility of using the positive experience in your personal work and the activity of your educational institution.

Table 1 presents the summarized results of the percentage for each presented innovation.

Table 1. Reflective questions 1. The results of the survey (in %)

Reflective assessment	open social learning	flipped classroom	bring your own devices	event-based learning	crossover learning	bricolage	computational thinking	adaptive teaching	stealth assessment
Regularly use in my work	0	0	16	14	7	5	13	11	12
Occasionally use in my work	29	20	26	49	33	25	26	39	8
Do not use, but would like to	45	46	26	29	37	60	48	36	65
Do not use, but my colleagues do	10	3	3	9	7	10	9	14	4
There is no technical possibility to use	10	6	23	0	7	0	0	0	4
Impossible to use due to the leaners	3	14	3	0	4	0	4	0	0
Do not accept this form	3	11	3	0	4	0	0	0	8

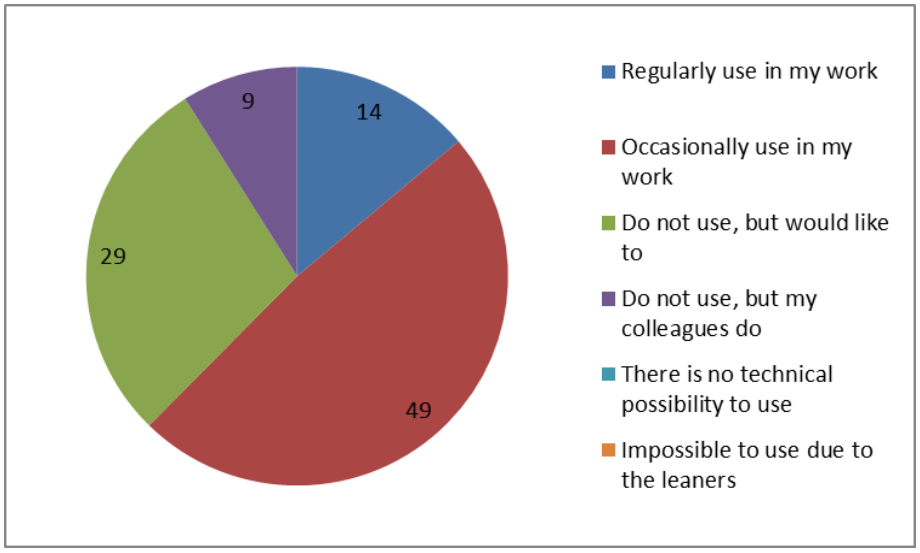

Figure 1. The results of the survey of pedagogical readiness to implement theevent-based learning

It is worth noting that the vast majority has strong motivation to use the innovative forms of organization of learning activities. The responses show the consent to use the proposed innovative forms or to support their use. The highest pedagogical readiness for the implementation of the innovative forms the mathematics teachers give to event-based learning (**Figure 1**).

The lowest pedagogical readiness for the implementation of the innovative forms the mathematics teachers assign to flipped classroom (**Figure 2**).

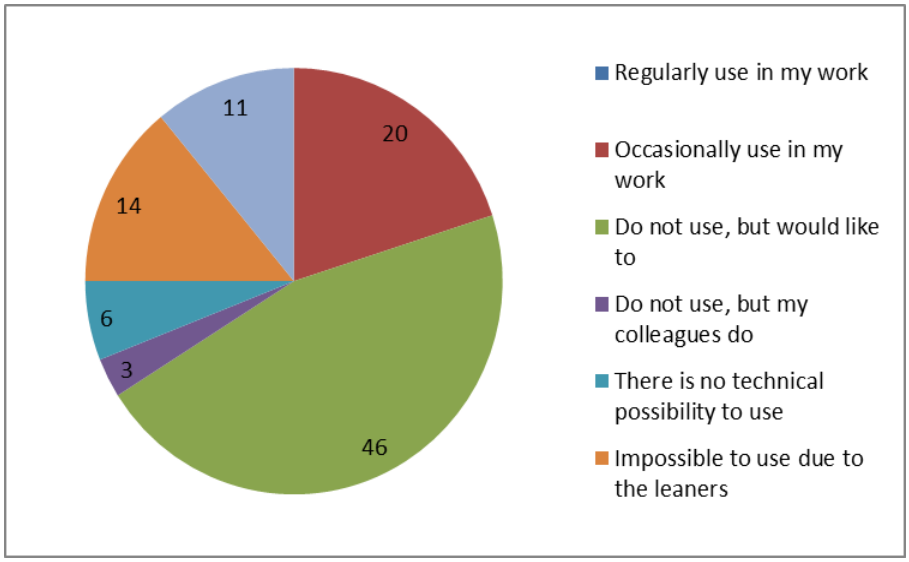

Figure 2. The results of the survey of pedagogical readiness to implement theflipped classroom

Table 2. Reflective questions 2. The results of the survey (in %)

Reflective assessment	Yes	No
It is necessary to use creative mathematics lesson according to the system NFTM-TRIZ.	97%	3%
It is necessary to periodically organize different activities, implementing the event-based learning	100%	0%
It is necessary to use the innovative form "Flipped classroom" to create a situation of success and creative development of the pupil	86%	14%
it is necessary to use TRIZ principles and tools when working with children	95%	5%
It is necessary to use in work unusual devices and techniques, show the connection of mathematics and life	100%	0%
It is necessary to allow students to use in class all possible sources of information, including the Internet	85%	15%

Table 3. Reflective questions 3. The results of the survey (in points)

Indicator	Mean score
The relevance of the covered issues	9.7
The pedagogical practicability of the covered issues	9.6
The novelty of methodological approaches	9.2
The attainability of educational results when using these approaches	8.9
The use of modern technologies	9.7
The provision of methodical resources	8.8
The consistency of presentation	9.5
The judicious mix of productive and reproductive forms	9.3
The validity of the main types of student activities	9.2
The detailed content	9.2

Reflective question №2. Rate what really can improve the level of creative development of pupils by means of mathematics.

Table 2 presents the summarized results of the respondents' answers.

We note that when giving responses to this question the participants aware the need for innovations in education and agree that the introduction of the positive experience is necessary.

Reflective question №3. Rate on the ten-point scale (0 – absent, 10 – fully carried out) work of the methodical teachers' workshop.

Table 3 presents the results in points for each innovation.

It should be noted that the results of the analysis of the methodological value for the teacher show the high importance of such demonstrations and increased pedagogical readiness for the implementation of the innovative forms of organization of learning activities.

According to the results of respondents answering reflective question №1, there were formed two experimental groups on positive practices, scored the majority of votes. So, for the experiment were selected: flipped classroom, bricolage, computational thinking, "stealth" assessment. For each positive practice 3 groups were formed that

Table 4. Proportion of teachers included in experimental and control groups on the most popular positive practices (in per cent)

Reflective assessment	Flipped classroom	Bricolage	Computational thinking	"Stealth assessment"
First experimental group	46	60	48	65
Second experimental group	34	10	13	16
Control group	20	30	39	19

divide the total number of participants (71 teachers) into 2 experimental and one control groups. The first experimental group included teachers with motivational readiness for positive practice implementation (teachers, who chose the answer "Don't use, but would like to" for these positive practices). The second experimental group composed the teachers with lack of motivational readiness for implementation of positive practices (teachers, who chose the following responses: " Do not use, but colleagues use", "No technical capabilities to use"," Impossible to use due to contingent" or "I do not accept this practice"). The control group consisted of teachers who use this positive practice, i.e. who chose the answers "Regularly use" or "Periodically use in my work." Summary proportion of teachers included in the experimental and control groups from the total number participating in the seminar on the most popular positive practices is presented in **Table 4**.

In the next stage of the experiment together with teachers of the experimental group we analyzed working programs and calendar-thematic plans on the subjects of "Mathematics" (for 5 and 6 grade) and "Algebra" (grades 7-9), "Algebra and beginning of mathematical analysis" (grades 10-11) for the 4-th academic quarter (or 3-d semester) of one of this teacher classes. The purpose of the analysis was to identify the sections of discipline to which popular positive practices could be applied. If the teacher belonged to several experimental groups, different classes or different sections of the discipline were taken for the experiment. The control group was requested not to change identified in the working programs forms and methods of work with the class.

So, basically, to use positive practice "Flipped classroom" we selected sections of mathematics teaching methods of performing identical transformations of expressions, solving equations, systems of equations, inequalities and systems of inequalities. To use "Bricolage" practice, teachers selected sections, forming the understanding of the statistical regularities in the real world and different ways of studying them, of the simplest probabilistic models and the ability to use understanding of the surrounding phenomena probabilistic properties while making decisions. For the implementation of "Computational thinking" practice, they dedicated sections developing the ability to use functional graphical representations to solve various mathematical problems, to describe and analyze real dependences. "Stealth" assessment was tested by the teachers for sections aimed at real situations simulating in algebra language, at the study of constructed models using apparatus of mathematics and the interpretation of the results.

For example, for the flipped class, teachers used open online resources on the topics of the lesson and the resources that they created themselves, including those created with the help of services provided by Office Mix.

To evaluate the dependence of teachers' motivational readiness to innovation implementation and the efficiency of innovation in the educational process, we took into account in the experiment the results of the final test on the selected topic of the discipline and the average mark for the previous academic periods (1-3 academic quarters or 1-2 trimesters). The results are presented in **Tables 5** and **6**.

It is worth noting that in the first experimental group, which included teachers with motivational readiness for innovative practices implementation, there has been significant results improvement for all considered practices. In the second experimental group, which included teachers with low motivational readiness to consider positive practices, we do not see any significant improvements in results. The effectiveness of given practices for this group remains at issue. In the control group, which is presented by teachers applying the positive practices, we observe insignificant results improvement.

Table 5. Experimental and control groups results

Experimental Groups	Flipped classroom		Bricolage		Computational thinking		"Stealth" assessment	
	Average mark for previous period	Final test results	Average mark for previous period	Final test results	Average mark for previous period	Final test results	Average mark for previous period	Final test results
First experimental group	4.0	4.3	3.9	4.1	3.8	3.9	4.1	4.2
Second experimental group	4.2	4.3	4.4	4.3	4.0	4.0	3.9	3.8
Control group	4.1	4.2	3.8	3.8	4.2	4.2	4.3	4.4

Table 6. The results changing after positive practice implementation

Reflective assessment	Flipped classroom	Bricolage	Computational thinking	«Stealth» assessment
First experimental group	0.3	0.2	0.1	0.1
Second experimental group	0.1	-0.1	0	-0.1
Control group	0.1	0	0	0.1

DISCUSSIONS

It should be stated that the tested innovative forms of organization of learning activities do not cover all the existing progressive innovative experience in the system of public education. Selected forms do not always show high efficiency in implementation. It is not only because of the pedagogical unreadiness to implement them, but also because of learners – whether they are motivated or not, younger or older, whether it is a village school or not. It is worth noting that the positive results of the assessment of readiness of teachers to the introduction of the innovative forms mean that teachers want to teach their subject so that the youth of today like it. The analysis of the results of readiness for the introduction of the innovative forms was carried out with teachers after the demonstration of progressive pedagogical experience in the subject. Teachers are not ready to use these innovative forms without being provided methodological resources. For that reason we consider it necessary that the department of education and pedagogical institutes to strengthen the methodological support.

The 4-th stage of the experiment results analysis allows us to make a number of assumptions:

- the readiness of a teacher to update work forms is more correlated with the improvement of educational results than the innovative form of education itself;
- the use of innovative work forms by teachers with low motivational readiness does not improve the quality of education;
- periodic independent testing by a teacher new forms of teaching may improve the quality of education;
- positive practices typical for the exact sciences "Computational thinking", "Stealth" assessment" showed less educational effect in teaching math than practices typical for a wide range of disciplines;
- the use of practices in mathematics lessons that engage objective and material models, such as "Bricolage", provides the best educational results in studying material by a team with motivational readiness to use this method.

CONCLUSION

The main results of the research may be considered a high level of pedagogical readiness of teachers of mathematics to introduce the innovative forms of organization of learning activities, such as: event-based learning, adaptive teaching, bring your own devices, computational thinking, stealth assessment. It should be noted that the teachers were motivated to use other innovative forms (e.g. flipped classrooms) if they were provided with methodological resources. It is worth stating that according to the respondents event-based learning is the most appropriate form of the innovation in school. The suggested generalized innovative forms of educational activity on the subject can become the basis for defining strategies of pedagogical innovations in the experience of educational institutions and teaching staff. According to the recital of the state program, pedagogical potential of Russian education is one of the highest in the world. The willingness of the teaching staff to use the innovation in their work was proved in our stud. It let us to believe that goals of modernization of education in Russia are reachable.

RECOMMENDATIONS

The material of this article can be useful for teachers, educators and heads of educational institutions seeking to greatly improve the quality of training, as well as for the evaluation and further adjustment of the innovative forms of educational activity. The results of this study allow to identify a number of scientific problems and trends for further consideration: 1) the deepening and extension of certain ideas that are stated the article and related to the accumulation of psychological and pedagogical potential of the use of innovative forms on a separate school subject; 2) development of scientific and methodological support for the widespread use of the described forms.

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