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Ill-Posed Problems as a Means of Information Competence Development

Problemas mal planteados como medio de desarrollo de competencias de información

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Content

ABSTRACT:

The relevance is determined by insufficient development of didactic means to raise the information competence level. The information competence have been identified: to determine missing information; to identify alternatives in the problem statement; to search for information needed to solve the problem; to complete the problem statement definition with data, to organize the data found (construction of a problem model); to detect a contradiction (information processing). The materials of the article can be of value to school teachers.
key words problem with missing data, problem with redundant data, ill-posed problem, information competence, competency-based approach, problem with discrepant data in the statement

RESUMEN:

La relevancia está determinada por el desarrollo insuficiente de los medios didácticos para elevar el nivel de competencia de la información. La competencia de información ha sido identificada: para determinar la información faltante; para identificar alternativas en la declaración del problema; para buscar la información necesaria para resolver el problema; para completar la definición del enunciado del problema con datos, para organizar los datos encontrados (construcción de un modelo del problema); para detectar una contradicción (procesamiento de la información). Los materiales del artículo pueden ser valiosos para los maestros de escuela.
Palabras clave: problema con la falta de datos, problema con los datos redundantes, problema mal planteado, competencia de la información, enfoque basado en la competencia, problema con los datos discrepantes en la declaración

1. Introduction

The concept of “competence” arose as a result of the Russian Federation entering the Bologna process. Taking into account the experience of European scholars, Russian

researchers have identified a number of key competences:

– Information competences;
– Learning and cognitive competences;
– Communication competences;
– General cultural competences;
– Axiological competences;
– Social and labor competences;
– Personal self-improvement competences (Abdullaev, 2015).

In a broad sense, competences should be understood as specific knowledge, skills and abilities that are manifested in practical activities and form the basis of developing personal qualities. I.V. Tishkova (2015) describes information competence as "activity skills in relation to information in educational areas and student subjects", as well as the knowledge of modern communication media (TV, tape recorder, telephone, fax, computer, printer, modem, copier, etc.) and of information technologies (audio- and video recording, e-mail, media, Internet). In terms of this study, search, analysis and selection of the necessary information and its transformation as a modus operandi that is part of the information competences are of interest therein.

Educational practice has been faced with immaturity of issues concerning methodological and didactic means for the information competence formation. E.G. Gelfman (1996), V.A. Krutetsky (1968), N.V. Metelsky (1989), A.F. Esaulov (1972) and others regard problems with missing or redundant data that have been named "ill-posed problems" as such means. The inadequately investigated developmental potential of such problems should be noted, especially concerning their influence on the information competence formation. The existing research predominantly focuses on types of ill-posed problems and their influence on the development of intellectual processes. A number of scholars have studied ways of applying ill-posed problems in mathematics (T.A. Bezusova (2008), E.G. Gelfman (1996), Z.P. Matushkina (2006) and others), as well as in physics (S.V. Kaplun and A.I. Pesin (1998)).

The problem of elaborating and implementing competency-based approach in the educational process has been dealt with by J. Hermes, T. Behne and A. Bich (2018;), V. Utemov and A. Masalimova (2017) and others. V. Utemov, A. Masalimova (2017) propose to regard the method of non-routine mathematical problems simulation consistent with the levels of their complexity as the main method for developing creative competences in middle school students. They have also presented author approaches to differentiation of creative mathematical assignments for middle school students in accordance with a system scale formed by adapting creative solutions to problems classified by the degree of their complexity and the quality of the results obtained.

The concept of "information competence" is found in I.V. Tishkova (2015), I.D. Belousova (2015). The authors address various approaches to defining the concepts of "competence" and "information competence"; present competence classifications of various researchers; analyze approaches to the information competences teaching in vocational education. S. Mortabit (2013) refers to work with scientific and mathematical texts as the most important component of the information ability to comprehend data.

The goal of the research was to identify the activity types aimed at developing information competence skills by means of ill-posed problems.

Achievement of the target goal is conditioned by the following objectives: to specify skills that are part of the information competence; to identify substantial components for dealing with ill-posed problems in terms of the information competence development; to conduct pilot testing to improve the skill formedness levels within the information competence.

The research hypothesis: effective development of information competence in students in the unity of all its components is ensured through the use of a set of ill-posed problems if:

– Ill-posed problems and problems that seem to be so are applied simultaneously;
– Solutions include such tasks that require: a) constructing a simplified model of an ill-

posed problem (with a sufficient amount of data) by discarding redundant data, or changing the requirements of the problem; b) supplementing the statement of ill-posed problems in order to transform them into well-posed problems based on any set of data;

– solutions include problem writing tasks using equations, diagrams, drawings taking into account the need to supplement the missing data.

2. Literature review

An integral characteristic of information competences is the concept of "information competency".

Two approaches to the definition of "information competency" can be observed. Followers of the first approach regard information competency as an ability to use a variety of technical facilities to gather and process information (O.N. Ionova (2007), V.F. Burmakina, M. Zelman and I.N. Falina (2007), K.K. Khener (2004) and others.). Viewed in this way, information competency can be equated with computer literacy. Followers of the second approach (D.S. Yermakov (2011), Ye.V. Petrova (2012), S.V. Trishina (2005) and others) define information competency by explaining its broad meaning, that is, the definition is based on proper information and the ability to handle it. This research pursues the second approach as well.

Information competency in the context of higher education is considered in the works of S.Yu. Astanina (2009), R.A. Baryshev (2016), O.A. Savelyeva (2013), V.V. Klimentyeva (2010) and others. These authors' papers deal with the issues of professional competency formation in university graduates against the background of society informatization. At the same time, the concepts of information culture and information competency are analyzed; stages of professional information competency formation in students are indicated. The article of V.V. Klimentyeva (2010) elaborates on the insight into the terms "information culture" and "information competency" in the field of professional teacher education, which is high on the agenda under the present-day conditions of the development of information technologies.

3. Materials and methods

The methods of research were:

1) Generalization and analysis of educational experience reported in psychological and pedagogical, as well as methodical literature;

2) Statistical processing of quantitative data on the formedness levels of skills within the information competence.

Pilot testing of the efficiency of the presented activity types aiming to form the skills included in student information competence was conducted in the academic year 2017–2018 in geometry classes for a 10th grade. 22 people from the control group (10 boys and 12 girls) and 19 people from the experimental group (9 boys and 10 girls) who agreed to participate in the study were involved.

To specify the level of information competence development in school students, the following methods were selected:

1) The Amthauer test designed to assess the numerical ability of testees (Tunick, 2009);

2) Sets of ill-posed problems of various degrees of complexity according to the skills that are part of the information competence.

The pilot testing consisted of three stages: ascertaining assessment, formative stage and control assessment, their goal and scope presented in Table 1.

Table 1
The objective and scope of the pilot testing stages

Stage name	**Goal**	**Scope**
Ascertaining assessment	Identifying the reference level of	Giving a test in geometry,

	formedness of skills included in the information competence of school students	administering the Amthauer test
Formative stage	Formation of skills that are part of the information competence of school students	Using the distinguished activity types to deal with ill-posed problems for formation of information competence skills in school students
Control assessment	Identifying the level of the formedness of skills that are part of the information competence of school students	Giving a test

At the first stage, the Amthauer test was given to students in the control and experimental groups (see Table 2, its major part copied from a resultant table of the *STATISTICA* system – the dialog screen *t-test for independent samples* used by the authors to analyze the experimental findings).

Table 2
Comparison of mean values of the Amthauer test results (10th grade)

	Mean G_1:1	Mean G_2:2	t – value	df	p
A1	14.55556	15.18182	-1.25475	39	0.217233
A2	12.72222	12.77273	-0.09116	39	0.927845
A3	11.50000	12.40909	-0.91443	39	0.366256
A4	16.55556	16.81818	-0.14043	39	0.889060
A5	8.33333	8.13636	0.14496	39	0.885510
A6	14.33333	13.31818	1.19217	39	0.240585
A7	13.44444	12.31818	1.69950	39	0.097398
A8	12.44444	12.54545	-0.12649	39	0.900010
A9	18.38889	16.90909	1.99930	39	0.052764

The tables contain:

– Mean values of the indicators for each of the nine subtests of the Amthauer methodology ("A1 is general awareness and knowledge in different areas of expertise (not only scientific but also commonsense), A2 is classification of concepts, A3 is drawing of analogies, A4–A5 are the ability to solve simple arithmetic problems, A6 is the ability to find numerical patterns, A7 is the ability to mentally manipulate images of three-dimensional figures on a plane; A8 is the ability to mentally manipulate images of three-dimensional figures; A9 is memorizing words");

– Mean G_1:1 stands for mean values of the experimental group;

– Mean G_2:2 stands for mean values of the control group;

– T-value stands for the values of Student's coefficients;

– df stands for “a number of the degrees of freedom equal to n1+n2-2, where n1 and n2 are the number of students in the experimental and control groups, respectively”;

– p stands for “a significance level at which the hypothesis about the mean values equality in both groups is true” (since for all the subtests, the significance level is greater than 0.1, with the confidence figure of 90%, differences in the groups are not significant statistically). Minus coefficients correspond to the fact that the mean values in the control group are higher than those in the experimental group.

The initial screening test results indicate that in the experimental and control groups there are no inherent differences in the components under consideration.

At the first stage, the students were asked to fulfill six tasks examining the formedness of skills included in the information competence (one problem for each skill); the method of N.V. Pekhotina (2017) adapted to the educational process in secondary school was partially used. Example problems are provided in Table 3.

Skills that are part of the information competence:

– The ability to determine missing information in the problem statement;

– The ability to identify alternatives in the problem statement (planning information retrieval of the missing data);

– The ability to search for information necessary to solve the problem in various sources;

– The ability to complete the problem statement definition with the data available in the problem “between the lines” (acquiring the necessary information);

– The ability to organize the found data (construction of a problem model);

– The ability to identify a contradiction (information processing).

Table 3

Example problems of the ascertaining assessment

No.	Competence	Example
1	the ability to determine missing information in the problem statement	"In triangle ABC, bisector AA_1 extends beyond the base to segment A_1E, and point E is connected to the point C. Find ∠ACE if ∠ACB=47º, ∠BAC=62º. (There is no unambiguous answer)."
2	the ability to identify alternatives in the problem statement (planning information retrieval)	Determine the shape of a quadrilateral with 2 pairs of equal sides 2 cm and 2 $\sqrt{3}$ cm long, and a diagonal 4 cm long.
3	the ability to search for information necessary to solve the problem in various sources	Determine the coordinates of vertices of a square whose diagonals intersect at the point with coordinates (7; –4), one of the vertices lying on the Oy axis. Are there enough data in the problem? If necessary, complete the statement, then solve the problem.
4	the ability to complete the problem statement definition with the data available in the problem "between the lines" (acquiring the necessary information)	"Segment AA_1 is the bisector of triangle ABC. Find A_1B if AC=30, AA_1=16, CA_1=20, and ∠AA_1B=∠B." Solution Method 1. $\frac{CA_1}{CA}=\frac{A_1B}{BA};\frac{CA_1}{CA}=\frac{A_1B}{A_1A}\Rightarrow A_1B=\frac{20\cdot 16}{30}=10\frac{2}{3}.$ Method 2. "Let us draw altitude AE in triangle ABC, denote the length of segment A_1E by x. Since $AC^2-CE^2=AA_1^2-A_1E$, then x=6.1. A_1B=2x=12.2, which does not correspond to the first method solution. Let us clear up the question of contradictory nature of the datum about AA_1 being a bisector. By the bisector property, $\frac{CA_1}{CA}=\frac{A_1B}{BA}\Rightarrow\frac{20}{30}=\frac{12.2}{16}$ must be fulfilled (false)." Answer: the problem has no solution. A problem with redundant conflicting data.
5	the ability to organize the found data (construction of a problem model)	The sides of a triangle are proportional to numbers 3, 4, 5. Can one of its angles be equal to 100°?
6	the ability to identify a contradiction (information processing)	"Line AK is drawn through vertex A of rectangle ABCD perpendicular to its plane." The distances from K to the vertices of the rectangle B, C and D are 3 m, 9 m and 7 m, respectively. Find a side of AK. (Conflicting data).

Also, the levels and respective criteria and indicators of formedness for the skills included in the information competence have been distinguished (Table 4).

Table 4
Levels, criteria and indicators of formedness for the skills included in the information competence

The ability to organize the found data (construction of a problem model using necessary and sufficient data)		
High level: the ability to correctly identify all cases in accordance with the problem statement is characteristic of students with a high level.	Average level is also characterized by a competent and rapid detection of all cases that correspond to the problem statement, but minor errors are allowed.	At low level, there are difficulties in determining cases that would correspond to the problem statement, as well as a limited number of alternate solutions.
the ability to complete the problem statement definition with the data available in the problem "between the lines" (acquiring necessary information)		
High level is characterized by knowledge of the logical procedure for finding contradictions and the	Average level is characterized by knowledge of the logical procedure for finding	Low level is characterized by the inability to apply the procedure for finding contradictions; serious

ability to compare statements and answers to a problem.	contradictions, but at the same time there are difficulties in substantiating (in this case, a student needs teacher's help); there are also some errors in solving problems, but with the simultaneous ability to detect and correct them.	difficulties in comparing a statement and the answer obtained; the presence of errors in solving contradictory problems and inability to detect them.
the ability to identify a contradiction, navigate an excessive amount of information		
High level is characterized by unambiguous determination of redundant data and the ability to test the problem statement for contradictions.	Average level is characterized by the presence of some errors in identifying redundant data, but at the same time by correct identification of contradictions, as well as some solution errors if there is a large amount of theoretical evidence.	Low level is characterized by errors in solution, but with teacher's help their detection becomes possible; correction of errors is difficult.
the ability to determine missing information in the problem statement		
High level is characterized by the ability to quickly construct a problem model on the basis of available data, as well as by unambiguous determination and inclusion of supplementary conditions.	Average level is characterized by the ability to identify the impossibility of solving a problem and the indication of those data that fall short of a solution, but errors are allowed (reducing the problem solution to several case studies that do not exhaust the solution).	The low level is characterized by the ability to identify the impossibility of solving a problem, yet, in the absence of the ability to provide options to meet its requirements.
the ability to identify alternatives in a problem statement (multivariance of outcomes) (planning information retrieval)		
High level is characterized by the ability to carry out a procedure of combinatorial enumeration of all cases corresponding to problem statement; the ability to suggest several possible supplements to the problem statement based on a presented variety of links and relations.	Average level is characterized by knowledge of the combinatorial enumeration structure, but in case of difficulties in the course of its implementation, teacher's help is needed.	Low level is characterized by a problem consideration in terms of a set of uncompiled facts; the inability to determine the type of problem; teacher's help is needed.
the ability to search for information necessary to solve the problem in various sources		
High level is characterized by the ability to specify information necessary to solve the problem (which information is available and which is not)	Average level. The student understands what information for solving the problem is missing. They are able to answer questions about information search in various sources, but they find it difficult to pose these	Low level. The student does not understand what information they need to solve the problem. It is difficult to find sources for extension of data definition.

	questions themselves.	

Each task was evaluated on a scale from one to three, whereat the results were summarized, and conclusions were made about the formedness level of skills included in the analytical-synthetic activity: from 0 to 6 points inclusive – low, from 7 to 13 inclusive – medium, from 14 to 18 – high. All calculations were carried out using the *STATISTICA* system. During the control assessment, it was requested to solve six tasks identical in the typology of ill-posed problems.

4. Results

The second stage of the experimental research involved a teaching experiment that was conducted on curated topics. The essence of the experiment was to change some variables (conditions) for the educational process implementation, but the rest of the conditions remained intact. Information components of the educational content in geometry presented in the 10th grade curriculum of general education institutions were referred to invariant variables (non-variable conditions) in the research. Variable conditions are represented by a set of ill-posed problems proposed in the process of teaching geometry.

The essence of the teaching experiment was that some requirements for classroom management were specified for the experimental groups of students at the beginning of training. The experiment was designed for 42 instruction hours on the following topics: “Parallelism of lines and planes” (20 hours); “Perpendicularity of lines and planes” (22 hours). Geometry classes in the 10th grades are taught on the basis of the textbook by A.V. Pogorelov (2012) and are planned for two hours a week. Classes were taught in accordance with the time schedule. The task contents were supplemented by ill-posed problems, that is, those problems determined by lesson planning were reformulated based on ill-posed problems construction techniques (replacing the problem statement data with more general concepts, supplementing the statement with consequences from the given data, changing the problem requirement through its specification, etc.). Note that different types of ill-posed problems were applied thereby. In addition, standard (well-posed) problems were proposed (along with ill-posed problems). Ill-posed problems were also included in homework assignments, as well as in independent and review work. In total, 80 ill-posed problems were solved. In conclusion, the learners were offered an assessment aimed at diagnosing the level of information competence development.

Substantial components for work with ill-posed problems of different types are described below.

Problems with missing data should be tackled through the prism of actions listed below.

1) Identification of missing data. If missing data can be determined (using reference literature or “between the lines” technique), this problem will be solved by applying different cases in accordance with the problem statement.

2) Using a simplified problem model with a sufficient amount of available data and solution of the obtained problem.

3) Solution of the problem, assuming the missing data is known. In this case, the solution is a function of the missing data.

When solving problems with redundant data, any data set that ends in necessary solution is used as a basis (for different solution paths, data sets vary). To check the solutions obtained, unexamined data are used that were not taken into account in solving the problem. If there are contradictions, several solutions can be obtained (individually with each piece of the conflicting data). After that, it is necessary to check the solution obtained for its consistency with practical observation. Sometimes an option is possible where both contradictory conditions are discarded, and a problem with missing data is solved.

Let us consider specifics of involving ill-posed problems taking into account didactic objectives of the lesson stage.

Objective: updating previously acquired knowledge and action methods.

At this stage, students reproduce the reference knowledge gained earlier or accumulated on the basis of first-hand observations. Ill-posed problems should not be complex at this stage; otherwise their use is not advisable. At this stage, well-posed problems that seem to be ill-posed (with missing data) are allowed. Such problem are normally solved by students independently but only after the new material has been studied. Organized in this way, student activities contribute to the formation of specific images and the ability to correct and clear reasoning in them. At this stage, problems with missing data and without an unambiguous solution with no additional conditions are also applied. By virtue of such problems, students develop a need for a broadened outlook and curiosity. Students are assigned the task to supplement the problem statement with missing data and to solve it. Including such problems in a lesson, a teacher facilitates review of the logical structure of basic concepts definition, promotes revision of theoretical provisions of educational material and the information competence formation.

Objective: formation of new knowledge and action methods.

The stage of new knowledge formation includes the application of ill-posed tasks through their elaboration in various situations and combinations with the aim of more fundamental and thorough acquisition of new material by the students. The solution of ill-posed problems at this stage allows for intrasubject communications establishment and helps to redouble students' attention to the focal points of the instruction material. This serves to deduce a significant theoretical position, as well as to update the facts already learned.

Objective: the formation, application and consolidation of learning aptitudes and skills.

Ill-posed problems at the stage of consolidation and practical application of the acquired knowledge hold a central position: they are aimed at ensuring comprehensive acquisition of knowledge and its further application in the conditions of primary generalization. Solution of ill-posed problems is accompanied by an explanation of the relevant rules and their substantiation. In the situation of primary consolidation, ill-posed problems are suggested in the case when students know solutions to standard problems to which the solution of an ill-posed problem can be reduced. For example, tasks like "Is there redundant datum in the problem?", "Can the theorem be applied in the postulated condition?", etc.

At this stage, more time-consuming problems are applied and, when necessary, they are to be solved by the blackboard with a detailed explanation. The role of a teacher in solving ill-posed problems at this stage is to focus students' attention on understanding the relationship between variables and comprehending the techniques and procedure of solution by posing clear questions. The teacher puts all kinds of ill-posed problems and assignments for their compilation into use.

In the control groups of 10th grade students, the conventional technique of teaching geometry was used. In the experimental class, changes were assumed in the content of problems, in the forms and methods of activity of students and the teacher. Based on introduction of the experimental material, the teacher contributed to the development of the information competence in the students, thereby achieving a better knowledge acquisition.

The logical procedure for introducing experimental material in experimental classes was that in the first lessons on the topic "Parallelism of lines and planes", standard problems prevailed, whereas in subsequent lessons, a shift was made first to problems with redundant data, whereby the data could also be contradictory.

Let us give an example of a problem: *"Through the endpoints of AB segment, 4.8 m long, parallel lines intersecting a plane at points C and D, respectively, are drawn. The length of the perpendicular dropped from point C to the line BD is 6.4 m. Find the length of the perpendicular dropped from point C to the line AB if the line AB does not intersect the plane and AC=7.2 m."*

In the course of evaluation, the student comes to the conclusion that the problem has no solution, since there is no parallelogram meeting the statement of the problem. The teacher focuses the students on constructing a figure on the basis of this statement of the problem, which contributes to a more profound analysis of them. Such tasks encourage formation of

the ability to consider the statement of a problem as a target of research.

For the ability for incisive analysis to be formed in students, they can be offered tasks with conflicting data, their requirements not being formulated as "find", but rather as "if exists."

Let us give an example of the problem: *"Is there a rectangle ABCD, whose sides are parallel to the sides of the quadrilateral A1B1C1D1, respectively?"*

Similar problems are written by reformulating problems from the textbook on specified parameters (without taking into account natural constraints).

After the process of investigating the contradictory nature of the problem statement has been proven, one can proceed to similar computational problems. In this case, students conduct a constructive research, whereby they should come to the conclusion that the problem statement is contradictory, and therefore it has no solution. At the same time, the teacher turns the students' focus toward identification of the reasons for the contradiction, establishing which they discover that the task is overflowed and then correctly formulate the problem statement. Note also that the learners also face the need to exclude redundant data. To do this, they proceed to the problem with missing data and write new problems, adding one of the statements to each of them.

Students are given the task to conduct research in order to determine whether the problems are formulated correctly. They solve each of them and come to the conclusion that these problems have a unique solution.

To conduct research on the statements of the constructed problems, students can construct geometrical figures that would satisfy the statements of the problems.

Then students are offered problems with missing data. At first, the students were offered a problem that required consideration of several cases.

An example of the problem: *"The ends of a given segment that does not intersect a plane are removed by 0.3 m and 0.5 m from it. How is the point dividing the given segment at the ratio 3:7 removed from the plane?"* The problem has two solutions, and optionality of the statement can be seen upon construction.

The teacher can ask clarification questions: find out how many solutions a problem has. Analyzing the statement of the problem, the students obtained two cases. Such problems show that the number of solutions can be determined without solving the problem itself. After studying ill-posed problems of this kind, the students are offered a problem that does not have a single-valued solution.

Schemes for processing the results of the ascertaining assessment for identification of the initial level of the information competence formedness in schoolchildren are presented in Table 5.

Table 5
Characteristics of information competence indicators in the experimental class (ascertaining assessment)

Experimental class	**Skill 1**		**Skill 2**		**Skill 3**		**Skill 4**		**Skill 5**		**Skill 6**	
	num.	**%**	**num.**	**%**	**num.**	**%**	**num.**	**%**	**num.**	**%**	**num.**	**%**
High	2	9.1	1	4.5	6	27.3	4	18.2	2	9	10	45.5
Average	12	54.5	13	59.1	6	27.3	15	68.1	13	59.1	9	40.9
Low	8	36.4	8	36.4	10	45.4	5	22.7	7	31.2	3	13.6

Table 6
Characteristics of indicators of information competence

in the control class (ascertaining assessment)

Control class	Skill 1		Skill 2		Skill 3		Skill 4		Skill 5		Skill 6	
	num.	%	num.	%	num.	%	num.	%	num.	%	num.	%
High	1	5.3	1	5.3	5	26.4	6	21.1	2	10.6	10	52.6
Average	8	42.1	10	52.6	7	36.8	7	36.8	10	52.6	7	36.8
Low	10	52.6	8	42.1	7	36.8	8	42.1	7	36.8	2	10.6

Classification gives a generalized picture of the obtained data distribution (Table 7).

Table 7
Comparison of the experimental and control groups
by the results of the ascertaining assessment

Information competence levels	Experimental group (10th grade)		Control group (10th grade)	
	number of students	%	number of students	%
Total	22	100	19	100
High	0	0	2	10.5
Average	19	86.4	13	68.4
Low	3	13.6	4	21.1

The results of the control assessment displayed significant changes and differences in the levels of development of information competence in students in the control and experimental groups. Let us consider the results of the training activities carried out in the 10th grade (see Table 8).

Table 8
Comparison of the average values of the investigated
parameters at the end of the pilot testing (10th grade)

	Mean_G1:1	Mean_G2:2	t-value	df	p
Skill 1	2.181818	1.894737	1.311134	39	0.197480
Skill 2	2.409091*	1.842105*	2.840281*	39*	0.007127*
Skill 3	2.272727	1.894737	1.678952	39	0.101157
Skill 4	2.090909	1.947368	0.660728	39	0.512671
Skill 5	2.272727	2.210526	0.337297	39	0.737702
Skill 6	2.363636*	1.947368*	2.072634*	39*	0.044862*

Addendum: the table lists the correlation coefficients (those denoted by * are statistically significant) between the corresponding indicators.

It can be easily seen that the students of the experimental class experienced significant changes in terms of selected indicators of information competency. Skill 2 (the ability to complete the definition of the problem statement with the data that is available "between the lines" in the task (retrieving the necessary information)) and skill 6 (the ability to independently search for the necessary information to solve a problem from various sources) are statistically significant.

Table 9
Characteristics of information competence indicators in the experimental 10th grade

Experimental class	Skill 1		Skill 2		Skill 3		Skill 4		Skill 5		Skill 6	
	num.	%	num.	%	num.	%	num.	%	num.	%	num.	%
High	8	36.45	10	45.5	7	31.8	7	31.8	8	36.4	9	41
Average	10	45.45	11	50	10	45.5	14	63.6	10	45.4	12	54.5
Low	4	18.2	1	4.5	5	22.7	1	4.5	4	18.2	1	4.5

Table 10
Characteristics of information competence indicators in the control 10th grade

Control class	Skill 1		Skill 2		Skill 3		Skill 4		Skill 5		Skill 6	
	num.	%	num.	%	num.	%	num.	%	num.	%	num.	%
High	1	5.6	2	11.1	4	22.2	5	27.8	1	5.6	4	22.2
Average	8	44.4	14	77.8	9	50	10	55.6	8	44.4	8	44.4
Low	9	50	2	11.1	5	27.8	3	16.4	9	50	6	33.4

Thus, we obtain.

Table 11
Comparison of the experimental and control groups based on the results of the control assessment

Information competence levels	Experimental group		Control group	
	number of students	%	number of students	%
Total	22	100	19	100
High (2.4 – 3 p.)	10	45.5	3	11.1
Average (1.7 – 2.3 p.)	11	50	9	50
Low (1.1 – 1.6 p.)	1	4.5	7	38.9

Comparison of the progress of students in the control and experimental groups confirms the performance efficiency. Thus, the conclusions drawn validate the hypothesis that the process

of forming information competence skills in schoolchildren with the help of ill-posed problems will be most effective if purposeful types of work with ill-posed problems are simultaneously used both as ill-posed problems and problems that seem to be so; problems are included that require: constructing a simplified (containing a sufficient amount of data) model of an ill-posed problem by discarding redundant data or changing the requirement of the problem; completing the statement of an ill-posed problem to obtain various well – posed problems based on any data set; tasks are used to write problems on equations, drawings, schemes, taking into account the supplement with missing data when necessary.

5. Discussion

As a result of the research it has been found that all types of ill-posed problems (problems with missing data the solution of which involves studying several cases, problems with missing data that do not have an unambiguous solution without significant supplementary conditions, problems with redundant data that do not contradict each other, problems with redundant data having a contradictory condition) have a positive effect on the development of information competence.

The research findings can be used by educational researchers to develop scientific substantiation and methodological recommendations on the formation of information competence skills not only for schoolchildren, but also for university students, as well as for practicing teachers in the educational process.

In general, one may talk of a positive trend in the formation of the skills of information competence in school students using the allocated content and types of work. In the course of pilot testing it was found that the materials and types of work described are effective.

6. Conclusion

The following objectives were set in the research: to distinguish skills that are part of the information competence; to identify substantive components for dealing with ill-posed problems that are advisable to use to form skills of information competence; to conduct pilot testing to improve the level of development of skills that are part of the information competence.

As a result of this work, the skills that are part of the information competence have been identified: the ability to identify missing information in the problem statement, the ability to see the optionality of the problem statement (multivariance of outcomes) (planning information retrieval); the ability to independently search for the necessary information to solve a problem from various sources; the ability to complete the definition of the problem statement data that is available “between the lines” in the problem (retrieving the necessary information); the ability to organize the data found (to compile a problem model using the necessary and sufficient data); the ability to identify a contradiction and to navigate an excessive amount of information (information processing).

Working with ill-posed tasks is focused on the development of the distinguished skills. A possible scope of development is determined by the typology of ill-posed problems. Each type of ill-posed problem can positively influence the formation of information competence components.

Note that a conscious effort aimed at formation of information competence among school students in the process of teaching mathematics has a positive effect on the formation of their divergent and convergent thinking, the ability to use the acquired knowledge in various situations and in various content areas.

The results of pilot testing of the content and types of work for the formation of skills of information competence among schoolchildren with the help of ill-posed problems have proved successful.

Further research trends are related to the distinguishing information competencies for higher education students.

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