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Monitoring the Students' Cognitive Interest in Math Class

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Abstract The article highlights one of the methods of measuring cognitive interest of the secondary schoolchildren in learning Mathematics and the results of its practical application. As a result of questioning pupils, there have been differentiated the factors influencing the interest in learning Mathematics. They are: understanding the course material, the complexity of the course material, the duration of mastering the uniform course material, the amount of the course material. It has been found out that the interest tends to spread from a teacher to a student, or from a student who displays a genuine interest to other students.

Keywords: *cognitive interest, training, course materials, mathematics, student, teacher, result*

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1. Introduction

The motivating force is a cognitive interest that encourages students to active learning and cognitive activities, making it a fascinating and full of emotions process. It is a well-known fact that acquiring mathematical knowledge by students is more successful if the interest in learning has been formed. If there is no cognitive interest, the quality of education decreases; the learnt theoretical material is quickly forgotten as well as the ability to apply it. Therefore, a teacher is to be able to define and control the rate of students' cognitive interest and to use the methods of monitoring it at Mathematics lessons.

2. Literature Review

The problem of the formation and development of cognitive interest is reflected in the works of modern Ukrainian (N. Bibik, B. Druz, G. Kulchytska, L. Lokhvytska, T. Sushchenko etc.) and foreign researchers (L. Bozovic, V. Bondarevskyi, N. Morozova, G. Piaget, S. Radko, S. Rubinstein, H. Shchukina, R. Cettel, A. Fabre, G. Frederick, B. Lopez, D. Super etc.). The analysis of psychological and pedagogical studies shows the complexity and multidimensional nature of the concept of "cognitive interest". The term is interpreted as a complex personality formation concerning various mental processes (L. Lokhvytska, S. Radko); integral formation that leads to the constant search for transformation by means of reality (G. Shchukina); effective teaching and learning activities (V. Bondarevskyi, B. Druz); a student's need of acquiring knowledge (L. Bozovic, N. Morozova); a steady student's trait (N. Bibik); an important learning tool (T. Sushchenko); a selective focus on individual mastering of the knowledge in a particular subject area (G. Kulchytska).

Leading researchers V. Bevz, G. Bevz, M. Ignatenko A. Kukhar, A. Scafa, Z. Slyepkan, N. Tarasenkova, A. Chashechnykova, L. Cherkaska, V. Shvets and others studied some aspects of the formation and the development of cognitive interest in learning Mathematics. This problem was considered by I. Garifullina [4] (pedagogical conditions of the cognitive interest development of junior schoolchildren in cooperation with nature), N. Tarasenkova [5] (development of basic school students' cognitive interest to mathematics by means of semiotics), O. Grebennikova [6] (project activity of the cognitive interests of high school students), Z. Druz [7] (custom tasks as a meaning of stimulating cognitive interests of junior students), N. Egulemova [8] (geometric problem as a means of the formation primary schoolchildren's cognitive interest), N. Zhytyenova [9] (cognitive interest formation of students of the 7-9 grades in learning the natural-mathematical subjects with computer support), A. Kuhar [10] (formation the cognitive interest to mathematics in the education process of the 4-7 grades), S. Shumyhay [11], I. Akulenko [13] (development of secondary and high school students' cognitive interest to study mathematics by means of science history) and others.

However, the methods of monitoring the level of students' cognitive interest at the lessons of Mathematics and the results of these measurements have so far been given an insufficient consideration in literature.

The purpose of this article is to highlight one of the methods of measuring high school students' cognitive interest in learning Mathematics and the results of its practical application.

3. Methodology of Research

To analyze the dynamics of cognitive interest at the lessons of Mathematics (by the method of I. Smirnova [2]) the questionning was held among the students of the 5-8 grades of the Cherkasy (Ukraine) secondary schools (№ 19, № 26), the Cherkasy (Ukraine) specialized schools (№ 3, 17, 28) and the Cherkasy Physics and Mathematics Lyceum. According to this method, at the beginning of the lesson, the students were given cards (Table. 1). At certain points of the lesson (the 5th min., the 10th min., …, and the 45th min.) the students were asked to record numerical values (0 to 9), which, in their opinion, corresponded to their understanding of the course material and interest to it. At the end of the lesson the teacher collected the cards and defined the level of cognitive interest as follows: ($I = \frac{\sum_{i=1}^{9} i n_i}{9n}$ (1)), n_i - the number of students who rated their level of cognitive interest value (0 to 9), n - the number of students in the class.

Table 1. The card, in which students record the numeric value (0 to 9)

1.	Time (min.).	5	10	15	20	25	30	35	40	45
2.	The level of your interest from 0 to 9.									
3.	The level of your understanding of the material from 0 to 9.									

This survey was held among the students of the 5th, 7th, and the 8th grades (531 persons).

In the 5th grade, in the time of the survey, the students studied the theme "Decimals", in the 7th grade - "The Signs of the Equality of Triangles", "The Sum of Triangle Angles", "Factoring Polynomials", "Functions and Graphics", in the 8th grade - "Square Shapes", "Square Roots and Real Numbers."

4. Discussion and Results

The questionnaire shows that cognitive interest depends on many factors (subjective and objective). Subjective factors are associated with a student's personality, their abilities, and goals and so on. There are objective factors influencing the cognitive interest.

4.1. The Level of Understanding of the Course Material

The dependence of cognitive interest level on the degree of understanding was fixed in Geometry class in grade 7. The theme of the lesson was "The Signs of the Equality of Right-Angled Triangles".

Figure 1 shows the shift of the students' cognitive interest level.

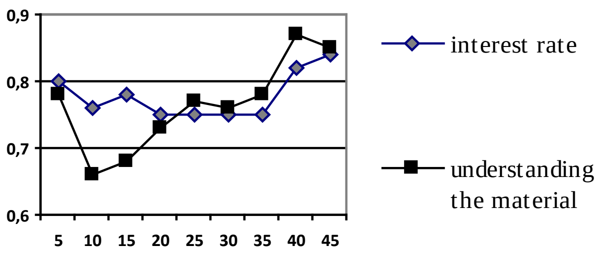

Figure 1. The results of the questionnaire concerning the influence of understanding the course material on the level of cognitive interest (Grade 7, theme "The Signs of the Equality of Right-Angled Triangles", the lesson of introducing to the new material)

At the beginning of the lesson, the teacher checked the performance of homework, with which most of the students had not coped with (the interest was decreasing). The difficulties with the homework performance were caused by the problems of finding the proof. This type of mathematical activity is rather difficult for the pupils of the 7th grade.

The students point out that their understanding level of the way to the proof is low (in fact, the students have not mastered the generalized way of finding the proof).

In the course of the actualization of basic knowledge (the 10th minute of the lesson), the teacher offered the students to indicate what triangles are equal and what the signs of equality are in Figure 2.

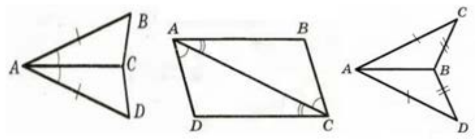

Figure 2. Problems for the basic knowledge actualization

The teacher offers the students to determine how many pairs of respectively equal elements are sufficient to determine and then to draw conclusions about the equality of right-angled triangles (Figure 3).

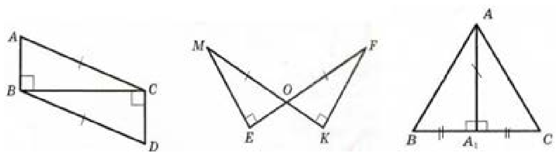

Figure 3. Problems for the **basic** knowledge actualization and motivation student's learning activity

It motivates further learning activity of the students. The level of students' understanding of the course material increases since they refresh their knowledge of: the definition of a right-angled triangle, the property of sides and acute angles of a right-angled triangle; the students refresh their knowledge as to the signs of the equality of arbitrary triangles. Hence, their interest is rising.

From the 15th to the 30th minute of the lesson, the teacher introduces new course material. The teacher proves the signs of the equality of the right-angled triangles (according to a leg and an acute angle, a hypotenuse and a leg, two legs); the students follow the proof. The level of understanding the course material is rather high; however, there is no increase of cognitive interest.

From the 30th to the 40th minutes of the lesson the students are offered problems 1-3.

Problem № 1. Name the right-angled triangles shown in Figure 4a). Name the legs and hypotenuse in each triangle. Are there equal right-angled triangles among the triangles if

$$AB = CD, \ AB \| CD, \ BM \perp AC, \ DK \perp AC. ?$$

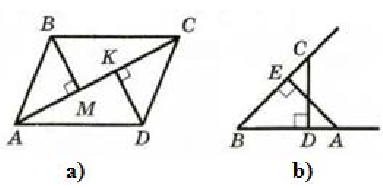

Figure 4. a). Problem 1, **b).** Problem 2

Problem № 2. Prove the equality of the right-angled triangles (Figure 4b) if $AB = BC$, $CD \perp AB$, $AE \perp BC$.

Collective solving of these problems and their discussion in groups are accompanied by the increased levels of understanding the new material and the growing interest of the students.

The research shows that at the first minutes of the lesson, the teacher has to make additional efforts to maintain the level of interest, to organize instruction in such a way as to increase the level of understanding of the course material.

Figure 1 shows that partial understanding is sufficient to encourage interest. Incomplete understanding, a desire to understand is the essence of encouraging the cognitive interest. When the material becomes clearer, the interest starts to decline (Figure 1).

We should keep in mind that the lack of the gap between the achieved level of understanding and the level that is to be achieved in the long term can lead to the decrease of cognitive interest.

4.2. The Complexity of the Material Being Studied

Complexity is the number of logical steps that you take to solve the problem. The research was conducted in Geometry class in the 7th grade. The theme of the lesson was "The Signs of the Equality of Right-Angled Triangles"; the aim of the lesson was the shaping of the students' skills.

Figure 5 shows the change of the students' cognitive interest level.

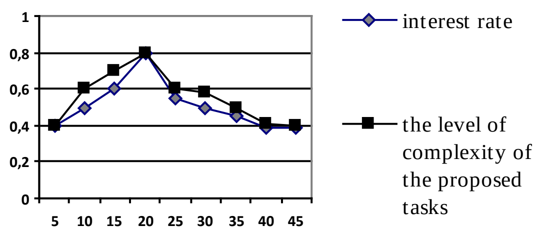

Figure 5. The results of the questionnaire concerning the influence of complexity level on cognitive interest (Form 7, theme "Equality Signs of Right-Angled Triangles; the lesson of mastering the learnt material)

Figure 5 shows how the complexity of the problems affects the cognitive level of understanding and students' interest.

From the 10^{th} to the 40^{th} minutes of the lesson the teacher was offering the students to solve the following problems.

Problem № 1. One of the acute angles of a right-angled triangle is 28° larger than the other one. Find these angles.

Problem № 2. One of the acute angles of a right-angled triangle is 4 times larger than the other one. Find these angles.

Problem № 3. Find a smaller angle between the bisector of the right angle and the hypotenuse of the triangle if one of the acute angles is 26°.

Problem № 4. Find a larger angle between the bisector of the right angle and the hypotenuse of the triangle if one of the acute angles is 64°.

Problem № 5. Given: point *H* is the intersection point of the two equal altitudes AH_1 and BH_2 in the triangle *ABC*. Prove that *AC* = *BC*.

Problem № 6. In the triangle *ABC AC* = *BC*, point *D* is an arbitrary point on the *AL* bisector of the angle *A*. Prove that *DA* = *DB*.

Problem № 7. There are two equal altitudes *AH* and A_1H_1 in the triangles *ABC* and $A_1B_1C_1$. The angle *B* is equal B_1, angle *C* is equal C_1. Prove that triangles *ABC* and $A_1B_1C_1$ are equal.

The ways of solving Problems 1-2 are approximately equal in terms of complicity level for the students in 7th grade. Problems 3-4 have a higher degree of complexity.

Figure 5 shows that if the complexity level of tasks does not change significantly (Problems 3-4, minutes 15-20), the interest begins to decline. But if the level of complexity of the problems increases dramatically (Problem 5-7, minutes 25-40), it also leads to the decline of the interest. Thus, the complexity level of the tasks should be didactically balanced. Solving problems is to promote student's "zone of proximal development" ([1]).

4.3. Duration of the Homogeneous Learning Material Acquisition

The research was conducted at the Algebra lesson in the 7^{th} grade. The theme of the lesson is "Difference and Sum of Cubes".

Figure 6 shows the change of students' cognitive interest level.

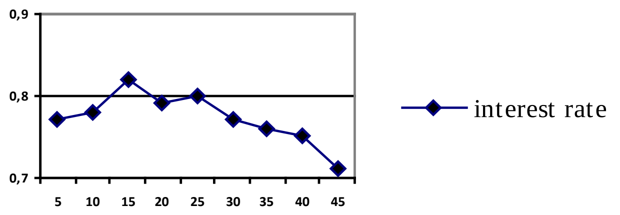

Figure 6. The results of the survey concerning the influence of the duration of the course material acquisition on the level of cognitive interest (7 grade, the theme "Difference and Sum of Cubes", the combined lesson)

Starting with the 25^{th} minute the students were solving problems (№1, 2).

№ 1. Factorize binomials:

a) $a^3 - c^3$; b) $27a^3 - b^3$; c) $27x^6 + a^3y^3$; d) $a^6c^9 - 27x^3$; д) $0,008 + y^3z^9$.

№ 2. Multiply the polynomials:

a) $(a-x)\left(a^2+ax+x^2\right)$; b) $(1-x)\left(1+x+x^2\right)$;

c) $\left(x^3-2a\right)\left(x^6+2x^3a+4a^2\right)$;

d) $(3x+y)\left(9x^2-3xy+y^2\right)$;

e) $\left(4a^{14}-2a^7b^4+b^8\right)\left(2a^7+b^4\right)$.

Figure 6 shows that the longer the students study how to solve identical or similar exercises the faster the level of cognitive interest declines (Figure 6).

Starting with the 25^{th} minute of the lesson, the level of cognitive interest decreases because from the 20th to the 40^{th} minute of the lesson, students solve problems, similar to the manner and method of solution. This form of work was not subjected to change.

Thus, solving the same type of the exercise should not exceed 20-25 minutes of the lesson, because the cognitive interest declines. If the exercises vary in terms of complexity, method of presentation or the form of solving exercise (group to the collective, the collective to the individual, etc.) changes, the decline of cognitive interest can be avoided.

4.4. Amount of Educational Material

The interest depends not only on the time but also on the amount of the course material. This dependence is the similar to the dependence interest on the time of solving. If the amount of the course material increases, the cognitive interest declines.

The research was conducted during the lesson in the 7th grade (theme "Factoring polynomials", the combined lesson", Figure 7).

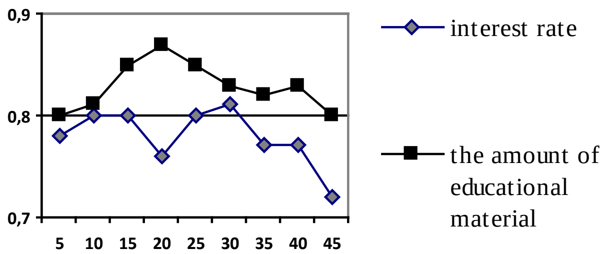

Figure 7. The results of the survey concerning the influence of the amount of the course material on the level of cognitive interest (Grade 7, theme "Factoring polynomials", combined lesson")

From the 5th to the 15th minute of the lesson, the students were factorizing polynomials using the ways of placing common multiplier outside brackets and the formulas of reduced multiplication (Problem № 1):

Problem № 1. Factorize polynomials:

a) $ap^2 - ax^2$; b) $27x^2 - 75$; c) $0,001a + a^4$;

d) $\frac{1}{8}z - \frac{1}{18}z^3$.

From the 5th to the 15th minutes of the lesson when the amount of the updated basic knowledge increased gradually, cognitive interest and understanding of the material were very high.

From the 15th to the 40th minutes the number of new methods that the students had to learn grew intensively: factoring polynomials by placing common factor out of the brackets, grouping, using formulas of reduced multiplication, the combination of all these methods (Problems № 3-8). There was an overload of the amount of the material, so the level of cognitive interest declined.

Problem № 3. Factorize polynomials:

a) $(a+2)^3 - 8$; b) $(z-1)^3 + z^3$; c) $64a^3 - (a-1)^3$;

d) $\frac{1}{8}a^3 + (1+\frac{1}{2}a)^3$; e) $1-(x+1)^6$.

Problem № 4. Find the numerical value of the expression:

a) $(x+1)(x^2 - x + 1) - x^3$, if $x = 5,73$;

b) $(z-2)(z^2 + 2z + 4) + 8$, if $z = 0,02$.

Problem № 5. Solve the equation:

a) $(x-1)(x^2 + x + 1) = x + x^3$;

b) $(x-3)(x^2 + 3x + 9) + x = x^3$;

c) $(y^3 + 1)(y^6 - y^3 + 1) = 0$.

Problem № 6. Prove that:

a) $321^3 - 123^3$ is divided by 198;

b) $321^3 + 123^3$ is divided by 111;

c) $15^6 + 1$ is divided by 113.

Problem № 7. Factorize the expression $x^5 - x^4 y + x^2 y^3 - xy^4$. The students should use the way of grouping, replacing the common multiplier outside of the brackets and the formula of cube sum.

Problem № 8. Factorize the expression $x^2 + 7x + 6$. The students should factorize polynomials presenting a member as a sum.

Thus, the teacher should remember that the optimal amount of new material for students should be 2-3 units of content (the definition of new concepts, math facts, and ways of mastering), otherwise, cognitive interest rate decreases.

5. Conclusion

The research made it possible to conclude that the Math teacher should: 1) have in store the methods of measuring the cognitive interest of students; 2) consider the dependence of cognitive interest on the complexity, amount of material, and the level of students' understanding; 3) use such property of the cognitive interest as the ability to spread on from a teacher to a student or from a student to a student.

We can point out that the interest tends to spread from a teacher to a student or from a student who shows strong interest to the other students. If a lesson is interesting for a teacher themselves, the level of students' cognitive interest increases considerably. Conversely, boring explanations of a teacher or flabby answers of students are the causes of declining of the cognitive interest. The teacher should make their explanations clear and interesting and encourage the students' answers to be the same.

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