



DIAGNOSTICS OF STUDENTS' MOTIVATION TO STUDY CHEMISTRY, MATHEMATICS AND BIOLOGY IN THE CONDITIONS OF PROFILED EDUCATION

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Abstract

Profile education involves the selection of subjects for learning. However, there is a problem of choice for many 15-year-old students in the conditions of profile education.

The students' choice of the education profile is related to the motivation to study the subject. But the students' motives may be different. These are not always internal motives.

Was the profile choice correct? What motivates students to study chemistry, biology, mathematics? What helps and what prevents the study of these subjects? The teacher can receive answers to these questions by means of diagnostics of students' motivation by specially developed method. The presented methodological and diagnostic materials to measure the motivation of 15-year-old students to study chemistry, mathematics and biology are aimed at increasing the effectiveness of pre-profile training of students.

Keywords: *educational motivation, students, profile education, pre-profile training, chemistry training.*

Introduction

Innovative development of the economy requires the training of specialists in mathematics, science and technology. In 2001 the Education Ministers of Europe set the objective of boosting enrolment in scientific and technical fields of study to contribute to the Lisbon process of fostering a dynamic and innovative knowledge-based economy.

Only the UK will need about 1.25 million scientists, engineers for innovative economic development by 2020. For years, educators have been agonizing over the decline in the number of secondary-school pupils studying the stem (science, technology, engineering and mathematics) subjects at A-levels. The most common explanation is that these subjects are perceived to be difficult (which they are) and therefore a bit risky for students wanting to ensure a place at a university of their choice (Naughton, 2016).

After loss of interest in science and growing interest in other majors, the third highest ranked reason for leaving science is poor teaching (Watkins, Mazur, 2013). Low interest of students in the study of mathematics and science has a negative effect on the development of science and technology related to these areas of scientific knowledge (Seymour, 2000).

According to PISA-2015 results the main Science scores are higher in the countries where students are more interested in science and they are lower in the countries where students are less interested in science (OECD, 2016). When students in OECD countries were asked about what happened at all or most lessons, almost seven in ten, that they can be ap-

plied to different phenomena, and half, that their teachers explain the relevance of science to their lives. Only one in four students, or fewer, they are said to have been allowed to design their own experiments or spend time in the laboratory doing practical experiments. Among students who attended at least one course at least six in ten students in Brazil, Costa Rica, Iceland, Montenegro, Poland and Spain reported that they never got to spend any more time in the laboratory doing practical experiments; and in Austria, Belgium, Finland, Italy, Japan, Korea and the Slovak Republic, more than one in two students reported that they were never or hardly ever asked to do research into test ideas (OECD, 2016).

The development of interest in the study of mathematics and science is important. A teacher can develop the interest of students if he uses an individual approach in the learning process.

The problem of raising up the motivation of 15-year-old students to study mathematics and Science becomes even more urgent in the conditions of profile education. So, at this age, students from 9 classes of Belarusian schools choose profile education in the following academic fields: chemistry and mathematics or chemistry and biology. Knowledge of students' motivation gives a teacher an opportunity to improve the effectiveness of their pre-profile training.

Diagnostics of Students' Motivation to Study Chemistry, Mathematics and Biology

A teacher can use the method of studying students' motivation by Lukyanova M., Kalinina N. (Lukyanova, Kalinina, 2004) in modification for mathematics and Science for increasing the effectiveness of pre-profile training of students.

The questionnaire for students and keys for processing the results are presented below.

Questionnaire for Students

Carefully read each uncompleted sentence and all the answers to it. Choose two answers for every sentence according to your opinion.

1. Studying mathematics and science at school is necessary for me to...

- A) to receive a good education*
- B) to enter the University*
- C) get a future profession*
- D) to better orientate in life*
- E) to get a good job*

2. I wouldn't study these subjects if ...

- A) they weren't demanded to study at school*
- B) I didn't live in my country*
- C) it would not be my parent's will*
- D) I didn't gain new knowledge*
- E) I didn't live*

3. It is pleasant for me when I am praised for ...

- A) good school marks*
- B) progress in study*
- C) the efforts made*
- D) my abilities*

E) the homework performance

F) my personal qualities

4. It seems to me that the purpose of my life is ...

A) to work, live and enjoy life

B) to know school well; to graduate from school

C) to benefit from people; to be useful to the society

D) to acquire knowledge

5. My goal at school lessons in mathematics and science is ...

A) to learn something new

B) to communicate with friends

C) to listen to and understand the teacher

D) to get a good mark

E) not to disturb anyone, to sit quietly

6. When doing my homework, I ...

A) carefully think about it

B) refresh the material learnt at the lesson

C) carefully read the tasks of the exercise

D) try to do all the homework at once

E) search for «ready homework» on the Internet

F) rest first

7. The most interesting thing at lessons in mathematics and science is ...

A) to communicate with friends

B) communication with the teacher

C) a new topic, new scientific experiments, solving computational problems

D) the teacher's explanation of the new material

E) to get good marks

F) to answer orally, to discuss problems

8. I study the material in good faith if...

A) it is interesting for me

B) I am in a good mood

C) I am forced to do it

D) I know that classmates will not help me in doing my homework

E) I need to improve the previous bad mark

F) always

9. I like to do homework ...

A) when it's quiet in the room and nothing distracts me

B) when it is not very big

C) when after doing it there is a lot of free time to take a walk

D) when I understand how to do it

E) when I have an opportunity to copy it from my classmates

F) at all times, as it is necessary to gain in-depth knowledge

10. My main motivation to learn better is ...

A) money that I will earn in the future having good education

B) my parents and (or) my teachers

C) my sense of duty

D) my low school marks

E) my desire to learn

F) my desire for better communication with my classmates and my teachers

11. I am more active at mathematics and science lessons if ...

A) I wait for an approval of others

B) I'm interested in the work being done (experiments, interesting tasks, etc.)

C) I need a good mark

D) I want to know more

E) I want to be noticed

F) the studied material is necessary for me (it will be useful in life, future profession)

12. My good marks in mathematics and science are the result of...

A) my hard work

B) a good teacher's attitude towards me

C) good preparation for lessons and good performance in class

D) my luck

E) my good knowledge

F) the help of my parents or friends

13. My successes in performing tasks at mathematics and science lessons depend on ...

A) my mood

B) understanding of tasks

C) my abilities

D) my effort

E) my luck

F) my attention to the teacher's explanation

14. I am active at mathematics and science lessons ...

A) if I know the topic of the lesson well and understand the material well

B) if I can cope with the tasks offered by the teacher

C) because I think it's always necessary to do this

D) if I know that the teacher will not scold me for the error

E) if I am sure that I will answer well

F) quite often

15. If any teaching material is not clear to me (difficult for me), then ...

A) I do nothing

B) I ask for help from classmates, teachers or parents

C) I accept the situation

D) I try to understand at all costs

E) I hope that I will understand this later

F) I try to remember the teacher's explanation and study the notes made at the lesson

16. If I make a mistake while doing the task, I ...

A) do it again and try to find and correct the error

B) lose my confidence

C) ask for help

D) apologize

E) keep thinking how to solve this task correctly

F) don't try to solve this task any more

17. If I do not know how to solve a task or do an experiment, I ...

- A) ask for help from classmates
- B) refuse to do it
- C) think and I look for ways to solve it
- D) do not do it, I copy it from my classmates
- E) carefully read the textbook
- F) feel sorrow and postpone the solution of the problem for a while

18. I do not like to do mathematics and science tasks if ...

- A) they require a lot of mental stress
- B) they are too easy, do not require my effort
- C) they should be done in writing
- D) they do not require ingenuity
- E) they are large and complex
- F) uninteresting, do not require logical thinking

Keys for Processing the Data

Questions 1, 2, 3 (questionnaire indicator **block I**) reflect the personal meaning of the learning. Questions 4, 5, 6 (**block II**) characterize the capacity for goal-setting. Questions 7, 8, 9 (**block III**) indicate different types of motives. Questions 10, 11, 12 (**block IV**) reveal the predominance of the student's internal or external motivation for learning. Questions 13, 14, 15 (**block V**) characterize the student's desire to achieve academic success or avoid failure. The realization of the student's aspirations to achieve success in studies or avoidance of failure allow us to determine questions 16, 17, 18 (**block VI**).

Each variant of the answer to questions 1–9 has a score that shows *the type of motive*: external motive – 0 points; game motive – 1 point; receiving a mark – 2 points; position motive – 3 points; social motive – 4 points; educational motive – 5 points (table 1).

Table 1. Keys for motivation indicators I, II, III of the questionnaire for 15-year-old students.

Answer options	The offered numbers and points corresponding to them								
	1	2	3	4	5	6	7	8	9
A)	5	0	2	3	5	5	1	3	0
B)	4	3	2	0	1	3	3	1	3
C)	4	0	5	4	3	5	5	0	1
D)	3	5	2	5	2	3	4	0	3
E)	4	4	5	-	0	0	2	2	0
F)	-	-	3	-	-	1	3	5	5
	I			II			III		
	Indicators of motivation								

To rule out randomness of elections and get more objective results students were asked to choose two options for answers. The scores of the selected answers are summarized.

Indicators of motivation I, II, III are the final level of motivation of adolescents calculated as the sum of points. According to the evaluation table, you can determine the levels of motivation for individual indicators (I, II, III) and the final level of motivation for adolescents (table 2).

Table 2. Score sheet for 15-year-old students.

Level of motivation	Indicators of motivation			The sum of points of the final level of motivation
	I	II	III	
Very high	26-28	24-27	22-25	70-80
High	22-25	20-23	17-21	57-69
Average	18-21	15-19	13-16	44-56
Low	15-17	9-14	7-12	29-43
Very low	1-14	1-8	1-6	1-28

The levels of motivation for **block I** show how strong the student's personal sense is.

Levels of motivation of **block II** show the student's ability to target.

The results of the data analysis for each of these indicators will help the school administration, teachers, parents, psychologist in solving the questions of formation of students' personal sense of teaching, ability to target.

Block III of the questionnaire allows to reveal the direction of motivation to the cognitive or social sphere. For this, it is necessary to calculate the frequency of elections of all types of motives for the entire sample of students. Then you need to determine the percentage of the types of motives and conclude that the predominant motives (table 3).

Table 3. Keys for identifying leading motive.

Answer options	Issue numbers		
	7	8	9
A)	G	P	E
B)	P	G	P
C)	L	Ext	G
D)	S	Ext	P
E)	E	E	Ext
F)	P	L	L
	Conventional symbols of motives		

Conventional symbols of motives: L - learning motive; S - social motive; P - position motive; E - estimated motive; G - game motive; Ext - external motive.

Block IV of the questionnaire (questions 10, 11, 12) allows to reveal the student's predominance of internal or external motivation.

Questions 13, 14, 15 are **block V** of methodology and they characterize such an indicator of motivation as a teenager's desire to achieve success in studies or avoid failure.

The questions of **block VI** of the questionnaire (questions 16, 17, 18) will help determine the feasibility of these motives in students' behavior.

The variants of answers selected by the students for the three named indicators (IV, V, VI) are estimated *using the polar scale* of measurement in points +5; -5. Responses which reflect the internal motivation, the desire to achieve success in learning, the implementation of behavior, are charged by +5 points. If the answers indicate external motivation, the desire to avoid failure about the passivity of behavior, then they are estimated by -5 points. The polar scale of measurement makes it possible to reveal the predominance of certain trends in motivation indicators IV, V, VI. The scores of the selected answers are summarized. Since students choose two answer options to complete each sentence, possible scores for each sentence (question) will be: +10; 0; -10. For each indicator of motivation (that is, in each content block - IV, V, VI) possible scores will be: +30; +20; +10; 0; -10; -20; -30 (table 4).

Table 4. Keys for motivation indicators IV, V, VI of the questionnaire (questions 10-18) for 15-year-old students.

Answer options	Issue numbers								
	10	11	12	13	14	15	16	17	18
A)	+5	-5	+5	-5	+5	-5	+5	+5	-5
B)	-5	+5	-5	+5	-5	+5	-5	-5	+5
C)	+5	-5	+5	-5	+5	-5	+5	+5	-5
D)	-5	+5	-5	+5	-5	+5	-5	-5	+5
E)	+5	-5	+5	-5	-5	-5	+5	+5	-5
F)	-5	+5	-5	+5	+5	+5	-5	-5	+5
	IV			V			VI		
	Indicators of motivation								

Therefore, if a student has each of these indicators:

- +30; +20 points - this indicates the student's predominance of internal motives over external (indicator IV), the pursuit of success in learning activities (indicator V) and the implementation of educational motives in behavior (indicator VI);
- +10; 0; -10 points - external and internal motives are expressed approximately equally, there is both the desire for success and avoidance of failures in

learning activity, educational motives are realized in behavior rather rarely;

- -20; -30 points - external motives over internal ones prevail, avoidance of failures in training activities over the pursuit of success, lack of activity in behavior.

To conduct a survey of students, we created an online questionnaire on the Internet based on the free Google.com service – *forms.google.com*.

In spring 2017 students of the 9th classes answered questions in computer classes. All computers in the computer class had the address of the questionnaire on the desktop on the Internet. The results of the processing the questionnaire are presented in the table 5.

Table 5. Results of processing questions.

Class	Block I			Block II			Block III			Blocks I, II, III			Level of motivation (I-very high, II-high, III-average, IV-low, V-very low)				Leading motives			Block IV	Block V	Block VI			
	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	sum	
	1 2 3	4 5 6	7 8 9	1...9	1 2 3	4 5 6	7 8 9	1-9	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
9B	19	9	11	39	II	IV	IV	IV	GP	PG	PExt	0	-20	-10											
9B	19	23	17	59	II	I	II	II	LP	GL	EP	20	0	10											
9B	16	6	12	34	IV	V	IV	IV	GP	PE	PExt	-10	-30	20											
9B	18	20	16	54	II	II	II	II	LE	PE	PG	0	0	30											
9B	22	23	16	61	I	I	II	II	LS	PG	EP	20	10	10											
9B	20	12	17	49	II	IV	I	III	GL	PE	PP	0	-10	20											
9B	19	19	12	50	II	IV	III	III	GP	PG	PG	0	10	-10											
9B	20	23	20	63	II	I	II	II	LS	PL	EP	30	20	10											
9B	17	25	14	56	IV	I	II	III	LE	PG	EP	30	10	30											
9B	19	23	15	57	II	II	II	II	SP	PE	EP	20	10	10											
9B	24	17	19	60	II	I	I	II	PL	PL	EP	20	10	20											
9B	25	25	22	72	I	I	I	I	LS	PL	EL	30	20	20											
9B	18	21	10	49	II	IV	III	III	GE	PG	EP	10	0	-10											
9B	21	20	11	52	II	IV	III	III	GE	PE	EP	10	0	20											
9B	16	23	22	61	IV	I	I	II	LS	PL	EL	20	30	10											
9B	17	23	18	58	IV	I	II	II	LS	PG	EL	30	10	20											
9B	18	22	20	60	II	I	II	II	LS	PL	EP	20	10	30											
9V	20	23	16	59	II	II	II	II	LS	PG	EP	30	30	20											
9V	12	21	15	48	V	II	II	III	PL	PG	EP	30	-10	20											
9V	16	24	17	57	IV	I	I	II	LP	PG	EL	10	20	20											
9V	18	19	14	51	II	II	II	III	SE	PG	PG	0	10	10											
9V	23	23	14	60	I	II	II	II	LE	PG	EP	20	10	20											
9V	18	21	16	55	IV	II	II	III	LS	PG	EP	30	-10	10											
9V	25	20	17	62	I	I	I	II	PL	GL	EP	20	20	20											
9V	22	16	14	52	II	II	II	III	GE	PE	PP	10	20	10											
9V	22	13	16	51	I	IV	II	III	LE	PExt	PP	0	0	0											
9V	19	18	13	50	II	II	II	III	PE	PE	EP	0	0	10											
9V	18	15	15	48	II	II	II	III	LP	PG	EP	20	10	30											
9V	17	12	12	41	IV	IV	IV	IV	PP	PExt	PExt	10	20	20											
9V	23	24	18	65	I	I	I	II	PL	PE	EL	20	30	30											
9V	20	22	18	60	II	I	I	II	LP	PE	EL	10	20	30											
9V	21	16	13	50	II	II	II	III	GP	PE	PG	-10	0	0											
9V	25	17	19	61	I	I	I	II	LP	PL	EP	0	0	20											
9V	19	21	13	53	II	II	II	III	GP	PE	GP	0	20	10											

1. The results of the survey on the first block show that the personal meaning of learning:

- High in 26.5% of students;
- Average in 50.0% of students;
- Below the average in 20.6% of students;
- Low in 2.9% of students.

The personal meaning of learning is one of the most important internal incentives for students. The data obtained revealed a serious problem. The solution of this problem can be facilitated by the use of situational problems with different contexts related to students' personal experiences.

2. The results of the survey on the second block show that the ability to target:

- Very high in 11.8% of students;
- High in 50.0% of students;
- Average in 23.5% of students;
- Below the average in 11.8% of students;
- Low in 2.9% of students.

3. *The results of the survey on the third block show that educational motives prevail in 39.2% of students, social motives prevail in 32.4% of students.*

- 67.6% of students believe that *the most interesting thing at the lessons is a new topic, scientific experiments and solution of computational problems.*
- 32.4% of students are *interested in listening to the teacher's explanations.*
- Another 32.4% of students are *interested in answering orally, discussing problems.*

Answers to these questions show that students are more interested in active learning activities in the classroom, and the teacher can pay more attention to discussing problems, students' opinions, the results of experiments, etc.

- 94.1% of students study the material in good faith, if it is *interesting for them.*
- 44.1% of students study the material in good faith, if *they are in a good mood.*
- 32.4% of students study the material in good faith, if *necessary to correct the mark.*

- Only 26.5% of students *always study conscientiously the educational material.*

These answers reveal insufficient willful efforts of students in training. Only interest and external factors, such as a mark, cannot give a good effect. However, a good mood is an important factor for many students.

Hence, a teacher should:

- create a positive emotional atmosphere in the classroom;
- assess the mastering by the student at each element of the educational material;
- compare the efforts and results of the student's work with his past efforts and results;
- show students a personal interest in the positive dynamics of their educational achievements.

Students like to do homework at home:

- *When it is quiet in the room and nothing distracts them (70.6% of students);*
- *When they understand the topic (55.9% of students);*
- *When their homework isn't big (41.2% of students);*
- *Always, because this is necessary for in-depth knowledge (only 23.5% of students).*

The answers to these questions reveal the problem of understanding the educational material, the problem of understanding the importance of its study.

They also show the importance of creating conditions at school and at home for the effective learning.

The final levels of student motivation were as follows (Figure):

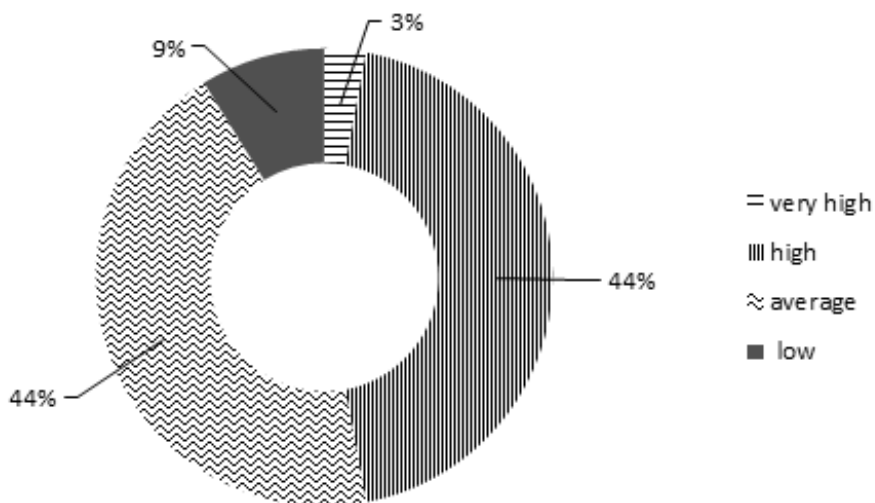


Figure 1: The final levels of student motivation.

4. The results of the answers to the questions (block IV) showed:

- Half of the students (50.0%) have an internal motivation.
- The remaining students have external and internal motives approximately equal.

5. The results of the answers to V-VII blocks of questions showed:

- 32.4% of students have a desire for success in educational activities.
- 3.0% of students have a desire to prevent failures in training activities.
- The remaining students (64.7%) present both the desire for success and the avoidance of failures.
 - 52.9% of students realize their motives in behavior, and 47.1% of students realize educational motives in behavior rather seldom.

In general, the results of the questionnaire have revealed important problems in the emotional-value and motivational-volitional spheres of a student's personality.

Possible solutions to these problems are:

1. A teacher needs to use problem situations more often, create a positive emotional background in class, note the success of each student in comparison with himself.
2. It is important to get feedback from the student's family in order to discuss with parents the issues of education of the will, the pursuit of success, the fulfillment of homework (creating conditions, etc.).

Summing-up

The presented methodology for measuring the motivation of 15-year-old students to study chemistry, mathematics and biology help to:

- identify students with a strong desire to achieve success in learning;
- determine the number of students with a high, average and low levels of motivation to study chemistry, mathematics and biology;
- draw conclusions for an individual approach to increasing the interest of students and using different approaches in teaching.

If cognitive and social predominate in the election of students' motives, teacher and students have good relations, he can attract children with a school subject. At the same time, students do not experience overload, assignments are accessible to them, their educational activity is successful, which generates internal motivation.

If only external motives prevail, then there are shortcomings in the organization of the educational process at school, in teaching methods, in the communicative sphere.

The use of diagnostics and analysis of the results gives the teacher the necessary information to improve the quality of pre-profile training and profile education.

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