Students' Motivation in The Process of Problem-Based Education in Chemistry and Environmental Sciences

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Abstract

The search for new ways to improve the efficiency of learning, the interest in education and the motivation for studying is a major task modern education faces, which largely determines its quality. The improvement and development of modern education is also closely related with the selection of various approaches that facilitate personality development in all its aspects: social, psychological, emotional, intellectual, cognitive, and cultural. The design and organization of an educational environment which stimulates and promotes such development as well as the efficiency of learning is a major priority for high school education. The present research characterizes certain advantages of problem-based education, while the results presented allow for an adequate evaluation of this type of education as a possibility for the enhancement of the learning efficiency, motivation and interest in Chemistry and Environmental Sciences in high schools.

Key words: education in Chemistry and Environmental Sciences, tasks assigned as part of the educational process, problem-based education, motivation.

Introduction

Observations on the practice of high-school education, as well as a variety of research studies demonstrate a steady tendency of decrease in students' motivation and diminishment of their overall interest in learning and teaching. The requirements that all educational activities are expected to meet on the other hand, turns the issue of educational efficiency into a serious problem to be solved especially as regards some of its particular dimensions such as awareness, participation, and interactivity. The other side of the medal in this situation seems to be the educational context partly definable as motivation, formation and development of scientific curiosity.

Problem-based education offers ample opportunities to create such educational context not only because it can be conducted both in the form of curricular and extracurricular activities, but also because it can be a way to affect interpersonal relations as well as the individual experience of the subjects that participate in it in such a manner that the educational milieu may be organized within the constructivist paradigm of learning and teaching. Problem-based education lies at the basis of the development of students' cognitive autonomy and their creative abilities [26].

Problem-based education, stages of realization, typology of tasks assigned as part of the educational process

Plamen Radev defines the following principles of education associated with the constructivist approach: principle of contextuality and situationality; principle for the stimulation of individual skills for organization, re-organization, integration and re-integration of student's knowledge; principle for the providing of individual knowledge construction based on prior knowledge and experience; **principle** for directing students interactively in the process of **task solution**; principle for culture-oriented and differentiated approach in schooling [28]. Some authors associate the occurrence of a problem with what is unknown and unfamiliar in a situation in which the subject (the student) has already set a goal even in cases when s/he does not know how to achieve it or does not have a clear-cut plan to do so.

In other words, there is an obstacle, a hindrance (usually an intellectual glitch). This is claimed to suffice as a motive to enhance the student's interest on the grounds of the innate desire to look for ways to remove the obstacle, e.g. to solve the problem [14]. A problem situation is a consciously or unconsciously held awareness of a difficulty the overcoming of which requires creative search for new knowledge, new opportunities for acting in a particular manner. When the subject becomes aware of this difficulty, acknowledges its existence, and manages to formulate it, it turns from a problematic situation into a problem [19]. Plamen Radev argues that "a problem situation generically precedes a problem; it is not only a mental phenomenon that occurs when one faces difficulties, but also a specific and controversial aspect of a relation between the subject, the task, the means for its solution, and the objective reality"[28].

There are diverse and various reasons for the occurrence of problem situations in the education in Chemistry and Environmental Sciences. An educational problem can be defined as "a reflection of a problem situation in the form of signs, a task from a variety of cultural and educational areas for whose solution students lack knowledge and skills and are forced to look for more resources coming from their competencies" [28]. Apart from the occurrence of a problem situation and the formulation of the problem (the task), problem-based education is also largely dependent on the environment (the context) in which it takes place. The specific characteristics of the subject who is to solve the problem are also of primary importance in that problems do not exist independent of the subjects engaged in their solution.

The solution of tasks assigned as part of the educational process (problems) is specifically characterized as a process in which students go through certain steps: analysis of the situation – evaluation of the familiar and the unfamiliar; formulation of a problem (task); design of a hypothesis; proving the hypothesis and explanation (conclusion) [21]. Yana Merdzhanova argues that the essence of the solution to a problem situation involves a transformation of the problem into a situation (its inclusion in a context) and a transformation of the situation into a problem (identification of the problem in the environment) [23]. In the framework of multisensory education, she arrives at the following major **stages of a technology** for problem solution: research of the problem (its nature, its identification and additional characteristics and components); analysis (based on experience, comparison, adjustment of the analogy); visualization (through the direct and indirect multisensory collection of information); selection of solution (in the process of a comparative analysis of alternatives, co-ordination, trial of solutions, selection of ultimate solution) [23].

Plamen Radev presents the following stages of the process of problem-based education: occurrence of a problem situation and formulation of the problem; spontaneous efforts to overcome the situation; selection of the chunk of necessary knowledge and skills and formulation of a hypothesis (an assumption employed in the preliminary explanation and solution); verification of the alternative way to prove or reject the hypothesis, hence the solution to the problem; formulation and presentation of the results of the solution; argumentation and evaluation of the solution; recapitulation of conclusions [28].

Analyzing Newel, Simon, and Anderson's model, Radev reduces its stages to the following: input state of the problem; problem space; solution to the problem; selection of operators for the overcoming of the problem space; solution to the problem (arrival at a target state) [28]. Others claim that problem solutions depend on de-problematization (transformation of the problem into a task); conceptualization (ideal projection – prediction and probabilistic solution to the task); solution [33].

In spite of the fact that in the context of problem-based education the teachers functions change, the choice of problems and tasks associated with them is still her/his responsibility [28]. From a constructivist perspective in philosophical terms wherein the major goal is the active participation of the subject cognizing the world in and through the situation in which s/he acts it is necessary to look for educational and cognitive tasks able to provoke situations which enable the transition from knowledge to action. That is, in employing of the principles and concepts of constructivism, we should not neglect the role of the teacher in problem-based education.

With problem-based education the teacher is the one to organize problem situations, to direct the students to formulating problems, to give help in formulating and checking hypotheses, to verify the validity of solutions [21]. Certain authors claim that nowadays teachers organize problem situations as regards their own idea of the average students' subjective experience and give pupils the opportunity to solve the respective tasks [33].

Quite reasonably, these authors focus their attention on the limitation of the possibilities for activating students' own reflective capacity. For this reason students efficiency in solving problems requires substantial preliminary work so that their activities be goal-oriented, expedient, and cohesive as their abilities to solve problems need be developed in specific contexts through premeditated establishment of situations leading to active participation of students in problem-based education.

Problems have been classified in diverse and numerous ways. According to the subject-based criterion they can be natural, social, or cognitive. If defined within the field where input data come from, they can be scientific, educational, practical, ontological. Still another way to classify problems is in view of the level of description of the problem situation (theoretical, empirical, methodological) or according to the level of generalization at which the description of reality takes place (global, regional), etc. Generally speaking, the analysis of the problem situation leads to the conclusion that one of its specific traits is the occurrence of a controversy between what is known and what is not; when there is deficiency of information in the course of the cognitive activity; or when the subject finds it difficult to communicate with other subjects. In this relation two types of problems have been identified: cognitive and communicative [33].

Other schools of study differentiate problems based on the extent to which they are structured (with respect to their definiteness, the familiarity with their parameters, the probabilistic character of their solution), as well as the level of their complexity, dynamicity, the specificity of the field where they occurred [14]. The classification of problems into well-structured and ill- structured has been suggested by D. Jonassen, who also puts forward a variety of models for problem solution and a specific design and grounding of the possibilities for the development of respective skills and abilities [12, 13]. The present study employs the classification differentiating problems in terms of the level to which they are structured. That is it is accepted that problems can be well-structured, medium-structured (partially, adequately) and ill-structured [13, 9, 8].

Well-structured problems have a high level of definiteness, all their elements have been presented, the information necessary for their solution is available. Very often the handling of such problems requires different algorithmic sequences [8], because they are well-defined and their description contains a possible solution [17]. They have predictable and familiar solutions which in most cases present a specific ratio between the choice of a solution and the elements of the problem [35]. Well-structured problems are characterized by a high level of definiteness of the input state, a preferred output state, adequate available resources, a limited number of logical operators; they have a single correct answer; they imply the application of a limited number of rules and principles which can be organized in a predictable and recommendable order. This order is most commonly determined in advance and has clear-cut parameters. Additionally, these problems include concepts and rules which are common to the area of studies that engenders them and are marked by clear solutions which lie within students' capacities. Their answers are often convergent, that is the relation between the choice of solution and all the possible problem states is known. Also, they have a preferable manner of solving in which the choice of solution, however probabilistic and preferable, is to a certain extent predetermined, e.g., they have simple solutions that are easy to memorize [12, 17].

With partly (moderately) structured problems there is as much information as is necessary to provide a partial definition of the problem and there is a certain level of indefiniteness, mostly related to the fragmentary perception of the existing or desired situation, as well as with a certain measure of vagueness concerning the possibilities to eliminate the discrepancies within that situation [8]. Moderately structured problems have a single correct answer but part of the information necessary to reach it is not available and needs to be collected therefore these problems require a creative approach. There is more than one possible way to solve them and they offer possibilities for different models for the elicitation of a solution, which suggests heuristic rather than algorithmic procedures and increases the chance for success but neither facilitates nor guarantees it [9, 8].

Ill-structured problems are highly indefinite because one or more of their elements are unknown (Wood 1983) or covertly known while the information necessary for the elimination of the discrepancy between the existing and the desired situation is rather limited or not present at all. The goals with such problems are defined against the background of a high degree of uncertainty or there are limitations which are not formulated or explicated [34]. In his meta-theory for the solution of ill-structured problems D. Jonassen et al. develop some of their basic characteristics by discussing and analyzing a variety of authors.

He concludes that these problems have more than one solution or no solution at all (a consensus on the solution is difficult to reach); there are a number of criteria for the evaluation of the solution which are sometimes incompatible; there is a high degree of indefiniteness concerning the content and the organization of principles, rules and concepts which are sometimes in conflict or the relations between them are not compatible in all cases, that is, they are largely dependent on the context of their realization; there are no prototypical cases because the elements of the problem have a different degree of significance in different types of context and interact with each other; no clear-cut means of definition and description are available and require that students express different opinions and persuasions in order to determine the proper course of action, to find and explain their own solutions and creative decisions [12, 17].

H. Leemkuil, T. de Jong, S. Ootes (2000) define the basic characteristics of problem-based education on the grounds of the cognitive components it employs (D. H. Jonassen, M. Tessmer, 1996): knowledge (information, concepts, rules, and principles); structured knowledge (design of information networks; semantic/conceptual networks and mental models); abilities to expand the knowledge (construction/application of arguments, employment of deduction and analogy)**; meta-cognitive abilities** (goal-design and goal-setting, distribution of cognitive resources, evaluation of the input knowledge, evaluation of the progress, checking for mistakes); **motivational components/components of the attitude** (making efforts, perseverance, active commitment); self-cognition (clarifying preliminary knowledge, clarifying socio-cultural knowledge, becoming aware of individual strategies and also of cognitive partiality or weaknesses) [17].

In the course of the realization of problem-based education in high school students present preferences to different kinds of problems as regards their capacities, attitudes and interests. The organization of the educational environment with respect to these characteristics defines the interest, motivation and attitude of the students in the course of problem-based education. According to the principles of the reflexive approach, the tasks assigned as part of the educational process should be formulated by the students not by the teacher. The success of this venture demands that the teacher educate the students to discover and define problems and to design tasks for their solution [33].

Students' interests and motivation as a foundation for the successful realization of educational cognitive activity

Motivation lies at the basis of all human activity; it is "a process and a state with a number of interactions and different variables (necessities, intensity of proclivities, provocative value of the goal, expectations, already functional models of behavior, conflicts and contradictions of motives, unconscious factors) acting as behavioral regulators" [28].

Undoubtedly, the efficiency and the quality of learning as an activity and a process with goal-oriented, active, constructive, situational, adaptive, cognitive pragmatic, and regulatory character is a function of students' motivation, the learning strategies employed, the cognitive techniques (instruments) of studying, the participation in the methods, technologies and forms that are being used, as well as the self-dependence of the student" [29]. Motives are rooted in needs, experiences, perceptions, concepts and persuasions and are manifested subjectively in emotions, desires, inclinations, aspirations, interests, ideals and dreams [4].

Modern theories of education treat learning motivation as "a state and a complex of different motives which explain and give grounds to human learning" [28], while the motive for learning is defined as "a construct, whose referents are: what provokes the student to study as well as the significant grounds, reasons and goal-setting factors which invoke students' learning" [28]. For this reason, "the educational cognitive interest is a fundamental cognitive motive for learning" [4], while "the cognitive motive is a fundamental component of motivated cognitive activities" [1]. Scholars of didactics and psychology define interests as important motives in human activities and commonly interpret these as "a component of the teleology of activity" [20], "a specific cognitive proclivity" [18], "a characteristic form of *subject-object* relation" [30], "a form of self-expression" [5], "a complex cognitive relation of the student towards objects and phenomena in the surroundings" [25]. Other authors contend that "interest is an integral psychological phenomenon which binds together in an in eliminable unity volitional, emotional and cognitive processes. It is manifested as an integral personality property related with its needs, motives, goals and occupation" [10].

Discussing interests as an intrinsic component of the structure of the personality, Yana Merdzhanova claims that "interests incorporate a cognitive component and represent an active cognitive proclivity corresponding to the goals of the individual. Interests are dynamic and complex structures; they change, adjust, and interact in the course of time" [24]. The definitions of interest discussed so far indicate its close association with needs and motives, as well as with the personality attitudes and relation to the activity performed and its results. For that matter, motivation and interests should be defined as fundamental constructs whose referents are directly related with students' attitude to the educational activity and its results as products of that activity.

The conception of this relation which prevails in recent research is its interpretation as a basic component of the structure of competence (viewed as a personality property) which is integrated in the corresponding system of competences. This preeminently operational level of students' relation to the educational process is directly associated with the students' interest and motivation for achievement and success. **The motivation for success** is a construct with the following referents: desire for success in the activity performed and its adequate appreciation and evaluation; aspiration for overcoming of obstacles with higher levels of difficulty, proclivity for solving more difficult and challenging tasks, desire to receive feedback for one's own abilities, aspiration to live up to standards of high quality [28]. This construct is crucial to the realization of problem-based education, to the character of its organization, to the opportunity it gives to form and develop key competences.

Although the terms "learning-cognitive motivation" and "attitude to learning" are similar, they differ from each other in a meaningful and functional way. While the study of cognitive training and motivation provides information about the existing hierarchy of motives in the students' minds, the attitude is seen as the degree of adoption and implementation of an action and its results. The ratio shows the characteristics of students' behavior, but does not reveal the reasons behind this behavior. Therefore, within the research it is necessary to study and assess the students' attitudes on their first level – the operational, recognizing the existence of a second, higher personal level which is related to the emotional, volitional and cognitive-oriented motivation. An important aspect of the student's attitude is the interest that makes it dynamically active state based on the students' satisfaction with the results. The attitude of the students towards their activities is integral to the overall orientation of the individual, expressed in specific cognitive situations. The interest as a relatively constant preference for activities allows the target and the main motive to match. The attitude is directly related to the personally important individual interest connected to the possibility of reflexive activity and evaluation rate of educational cognitive situations. The course of the interest is directly connected to the nature of the relationship, manifested in terms of cognitive activity. Thus, forming a positive attitude in the students towards the activities will result in rationalization of the cognitive situations associated with the formation and development of core competencies.

Design of the research

The main components of the methodology of the study are directly related to its design and implementation. The object of the research is problem-based learning in chemistry and environmental science education in secondary schools. The subject of the study is the motivation and the interest of Bulgarian students in the course of problem-based education. The research on the effectiveness of learning, interest and motivation of high-school students in the course of problem-based education was conducted for a period of one year in the teaching process of Chemistry and Environmental Science. The contingent of the study are 70 students from grades 9 and 10. The goal of the experiment is to diagnose the academic motivation and interest of students in the course of problem-based education in chemistry and environmental science.

In order to achieve its goal and solve the problems related to the efficiency of learning, the exploration and evaluation of students' attitudes towards problem-based education (students' claims, motivation and interest) and its results, the study employs: 1) tasks specifically tailored to the cognitive material to be taught (structured, partially structured and ill-structured problems); 2) a map for direct exploration and assessment of the level of motivation in the course of the educational activities; 3) a test for academic motivation. Both the control group and the experimental group were evaluated through a system of standardized tests. The study of students' cognitive-and-educational motivation, as well as their claims and attitudes is conducted on two levels: 1) diagnostics through the research and assessment map is performed to investigate and evaluate the level of motivation in the course of the educational and cognitive modeling; 2) the level of academic motivation in the subject within the teaching experiment is examined.

The map for the exploration and assessment of the level of motivation employed in the study is developed by V. K. Gerbachevski [22] in order to diagnose the components of motivational structure associated with the level of claims in the course of educational activities. The questionnaire which is used meets the requirements of objectivity, reliability and validity. It was completed by students on the basis of their solutions to tasks assigned as part of the educational process. The person conducting the survey points to a certain moment in the process of solving in advance after which the students fill out their assessment cards and continue working on the assigned tasks. Each student received the following instructions: "When you reach the fixed moment in the process of solving the proposed problem, take the questionnaire form, carefully read the instructions and proceed to answer. Remember that the questionnaire refers to a moment when a part of the problem has already been solved, but there is still some work to be done. While working on the questionnaire, you should read each of the statements, select one of them, and decide to what extent you agree or disagree with it. Based on this consideration, you should circle one or another option. All the statements in the questionnaire relate to what you think or feel when your work on the educational and cognitive problems is interrupted" [22].

The main purpose of using the questionnaire is to study and assess the level of students' motivation in the course of solving educational problems. The analysis of the results of this survey, conducted during the educational activity, makes it possible to track and differentiate students' attitude to solving educational problems and assess their place in the learning process at two particular levels (the adaptation of the map): 1) the operational level concerning motivation and interest; 2) the personal level concerning the different orientations of motivation and interest - emotional, cognitive and volitional.

A learning motivation test was employed to achieve the aim of the study and to explore in detail the level and the dynamics of motivation. The test is developed by T. E. Dubovitskaya in order to diagnose the focus of students' motivation to study school subjects [6]. This test does not examine the motivation for learning activities in general. It focuses on the specific motivation for learning activities occurring in the course of studying specific subjects. The methodology consists of 20 conclusions with 4 possible options suggested in response to each (true, closer to true, closer to false and untrue). In the contents of the questionnaire there are no judgments regarding the personality of the teacher - the students describe how they feel during the lesson. The methodology is intended for all categories of students older than 12 (i.e. after 6th grade) who are capable of self-evaluation and self-analyzing. The test is translated and adapted to the Bulgarian system by S. Stoyanova; its reliability and validity have been checked (constructive and criterion-based) and as the author mentions, "the adapted test possesses good psychometric parameters and can be used to measure the students' motivation for learning" [31].

Although the concepts are similar - the educational and cognitive motivation and the students' attitude to learning and that it can be seen as the level of adoption and implementation of the requirements for students in the process of training, they have some differences in their contents.

Despite the widely-accepted view of the similarity between the concepts of *educational and cognitive motivation* and *students' attitude to learning*, which are commonly defined as the extent to which students adopt and implement educational requirements in the process of training, the two concepts do not overlap completely. The attitude to learning shows the characteristics of students' behavior, but does not reveal the motives of this behavior and the driving forces of learning. Only the diagnostics of cognitive-and-educational motivation can give an idea of the existing hierarchy of motives in the minds of the students. This hierarchy is reflected in the level of the educational and cognitive motivation - high, medium or low [16]. The aim of the research, which is related to diagnosing the performance and the learning attitude of students to the activity and its results, is directly connected to the diagnostics of cognitive-and-educational motivation and interest of the students in the implementation course of the overall study - their dynamics and the degree of manifestation. Arguably, educational-and-cognitive motivation determines the learning results as a whole and is thus subject to changes; also influences the didactic technology for implementing problem-based education to high-school students.

Analysis of the results

The main purpose of the diagnostics is associated with evaluating the effectiveness of learning and exploring the impact of motivation changes during problem-based education (registered through testing and observation) on the motivation for studying the school subject to which it is being implemented.

The comparison of the results of the final test clearly shows a significant difference in the results of the experimental and the control groups. The empirical value of Student's criterion is temp = 2,87, and the tabular value on the significance level $\alpha = 0,05$ is $t_\alpha = 1,98$. It is evident that temp> t_α (2,87> 1,98), (sig. (q) = 0.01<0.05 - significant difference). Since the empirical characteristic of the hypothesis is bigger than the theoretical one, we reject the null hypothesis according to which the difference between the average rating is random, and recognize that it is statistically significant, i.e. due to the consequential factors. Consequently, the average ratings (in terms of the number of points obtained in the test) of the experimental and control groups were statistically distinguishable in the final examination. This statistically significant difference shows the efficiency of specific technology of problem-based education employed in the study.

The effectiveness of learning within the course of educational activities is assessed by the magnitude of the effect of the experimental impact, which is determined by modifying the dependent variable, an indicator of which is d (di) in Cohen. The testing of the hypothesis and the determining of the magnitude of the effect in both groups (control and experimental) are complementary procedures. The verification of the hypothesis shows that the experimental impact has a reliable effect. Generally, researchers explain whether the differences between the mean values appear statistically significant and determine the relative strength of the effect of the experimental impact [11]. The magnitude of the effect in this particular survey is quite high: d = 1,42 (>> 0,8). It demonstrates the effectiveness of problem-based education with respect to students' learning and their achievements in natural and environmental sciences.

As discussed earlier, in the course of several classes, students are assigned a task of solving specific educational and cognitive problems of different types which they can choose from and asked to fill out a questionnaire in the process of problem solving. The person who conducts the survey has fixed a certain moment of the process in advance when students are expected to complete their assessment forms. After doing so, they can proceed with the rest of the work. The level of the educational and cognitive motivation in the course of solving this problem is measured as regards the degree of its manifestation - high, moderate or low level of the students' responses to success or failure, increase or decrease in the willingness to work on the problem. The research gives priority to the analysis of the motivation for achievement; it occupies a significant place in the motivational regulation of the learning process, dramatically influencing students' objectives, activities and efforts and determining the behaviour of individual students in the situations thus established.

The analysis of the results shows that, at the beginning of the study, 47% of the students reacted indifferently to their results and for 25% of them the task was of no particular interest. 62% were ready to become involved in everything but the survey. At the end of the study, only 18% were indifferent to their results, but 63% of them associated the task of solving a specific problem with something interesting. 58% of students were indifferent to their results at the beginning of the experiment, while 73% of the informants at the end of the experiment demonstrated active interest in the activity. A clear trend is noticeable in the analysis of the results in which 69% of the students at the beginning of the experiment felt that they cannot deal with it successfully, while at the end 75% of them thought that they had achieved a certain measure of success. Some of these results are related to the emotional focus of the students during the activities and are indicative of their motivation in the course of problem-based education.

At the beginning of the experiment, 72% of the informants showed indifference to their success. They were even nonchalant to whether their results would outstrip those of their peers. This shows that students do not have a proclivity to search for opportunities or try out different alternatives for achieving success in solving a task. All this is related to the students' desire to avoid low scores after completing an assignment. At the end of the experiment, 74% wanted to avoid a possible low score, while the score was important for only 7% of students at the beginning. 63% of the students show a prominent desire to achieve the best results at the end of the experiment, while at the beginning only 13% of their peers wanted to rank first in the test. Although at the beginning and the end of the experiment about 37% of the students considered the survey a difficult task, at the end of the 49% of them were ready to do everything in order to achieve the final goal, while only 17% of the students showed such readiness at the beginning. 88% of the informants were interested in the limits of their capabilities at the end, while 12% of them were nonchalant to this issue at the beginning. It can be summarized that there are three levels of motivation for achievement in the course of educational and cognitive modeling - high, medium and low, and the distribution of the respondents is presented in Figures № 1 and 2.

The results regarding the level of motivation in the course of problem-based education in the high school level of secondary education are statistically significant and provide a better understanding of its impact on the motivation for achievement, which is extremely important for the entire educational and cognitive motivation. Although the study of motivation is a very complex process involving various factors that guide, regulate and maintain the individual actions in the learning process, exploring it in the course of problem-based education, makes it possible to draw conclusions about the attitudes of students towards the activities and their results.

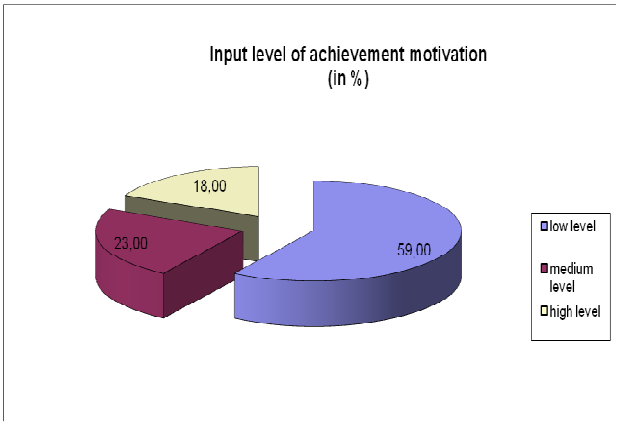

Figure № 1.

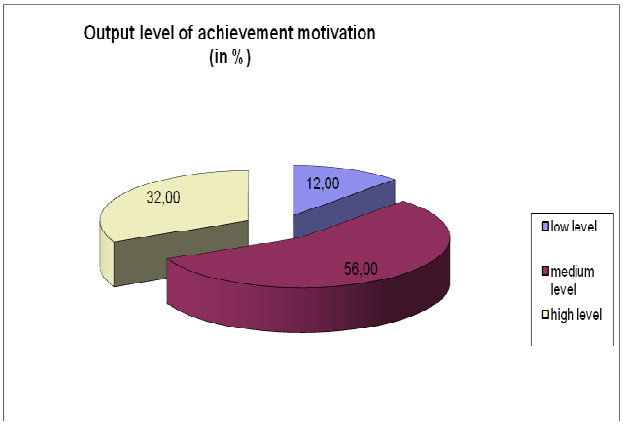

Figure № 2.

In order to establish a correlation between success in solving a task (requiring the solution of a specific problem) and the level of motivation, chi-square (χ^2) method is used because the empirical data are represented by variables of two scales - Y-axis (success) and nominal (the level of motivation, which is characterized mainly qualitatively). If we accept the null hypothesis (N_0), which states that there is no logical connection between students'success in the course of the problem-based education and the level of motivation for excellence, the alternative hypothesis states that this link exists. The empirical characterization of the hypothesis is $\chi^2_{emp} = 7.56$, while $\chi^2_t = 5, 38$ ($\alpha = 0, 05$). The comparison between the theoretical and the empirical features of the hypothesis, namely $\chi^2_{emp} > \chi^2_t$ (7.56> 5.38), gives grounds to reject the null hypothesis and to agree with the alternative, which means that there is a logical connection between success in problem-based learning and the students' level of motivation for achievement.

Developed by T. E. Dubovitskaya, the diagnostic test of the focus of motivation is not intended for the exploration of motivation in general, but for the specific motivation for a given learning activity which occurs in the studying of specific subjects. As pointed out earlier, the methodology originally consists of 20 judgments with proposed four options for each – true, closer to true, closer to false and untrue [6]. To facilitate the analysis of the responses, the possible answers are summarized and reduced to 2 - true and false.

The factor analysis of the test, whose reliability has been validated for the Bulgarian educational system by S. Stoyanova [31] shows that the items can be summarized in three factors as follows: Factor I includes items related to knowledge of one's own self and self-realization, self-reliability in studying the subject, interest in the subject because it corresponds to the aspirations of the individual, the active commitment to the subject during one's leisure time. This factor can be called "I study because I like being able to cope on my own and gain knowledge of myself." This factor, according to E. L. Deci and R. M. Ryan, corresponds to the integral regulation - the individual performs actions related to self-fulfillment [3]. Factor II includes items which relate to the interest in the subject, the learning of difficult tasks, and the strife for understanding the nature of the valuable, important and necessary knowledge obtained in the process. This factor can be called "I study because I find it beneficial." It corresponds to the identification regulation (actions are important to the individuals, they have personal meaning and value), according to Deci and Ryan (1985). Factor III includes items that relate to the requirements of the teachers, the reluctance to learn, the work contingent on the supervision of the instructor rather than on the personal aspirations, the lack of anxiety when the individual is not well prepared, the difficulties in the subject, which require more work.

This factor can be called "I study because my teacher forces me to do so." The results of the testing of the students in the experimental group are graphically presented below in Figures 3, 4 and 5, which summarize the results of the analysis of Factor I (Figure № 3), Factor II (Figure № 4) and Factor III (Figure № 5).

It appears that, at the beginning of the study, only 23% of the informants believed that learning is something they like because they want to do it on their own. This refers to their self-knowledge and self-realization, self-reliability in studying a subject, their interest in the subject because it corresponds to the proclivities of the individuals, the active commitment to the subject during leisure time. There is a very large contingent of students who believe that this is not true - 77% at the beginning of the study. Using problem-based education tends to increase students' interest in learning. At the end of the study over 38% of the students learn because they like this.

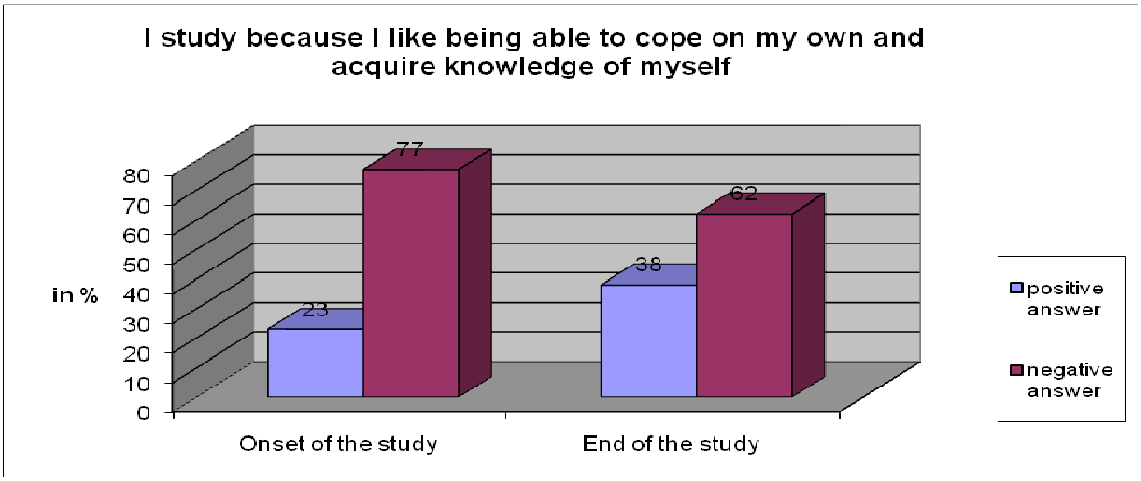

Figure № 3. Results from the test of students' educational motivation - factor I

Factor II refers to the interest in the subject, the handling of difficult tasks, the strife to understand the nature of learning, to obtain valuable, important and necessary knowledge. The majority of the students get to recognize the usefulness of learning - 85% at the end as opposed to only 38% at the beginning.

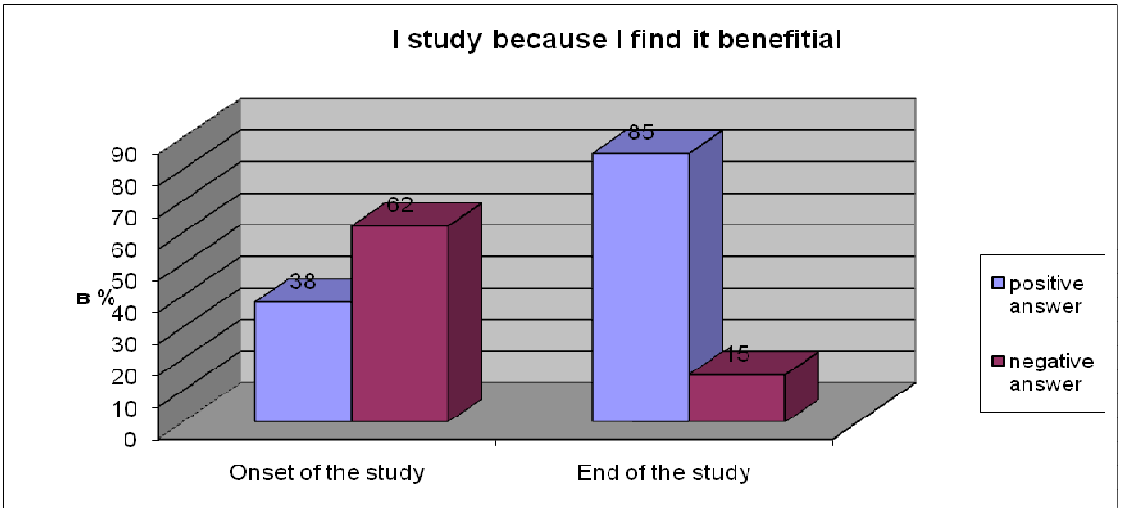

Figure № 4. Results from the test of students' educational motivation – factor II

The application of problem-based education in high schools leads to a reassessment of the position of the teacher by the students. Before the research, 62% of the students considered learning an obligation imposed by their teacher, while for 72% of the informants at the end of the study this is not the case.

Factor III relates to the requirements of the teacher, the students' reluctance to learn, the contingency of students' participation on the supervision of the instructor, the lack of anxiety when the individuals are not well-prepared, the difficulties in the subject, which require more work.

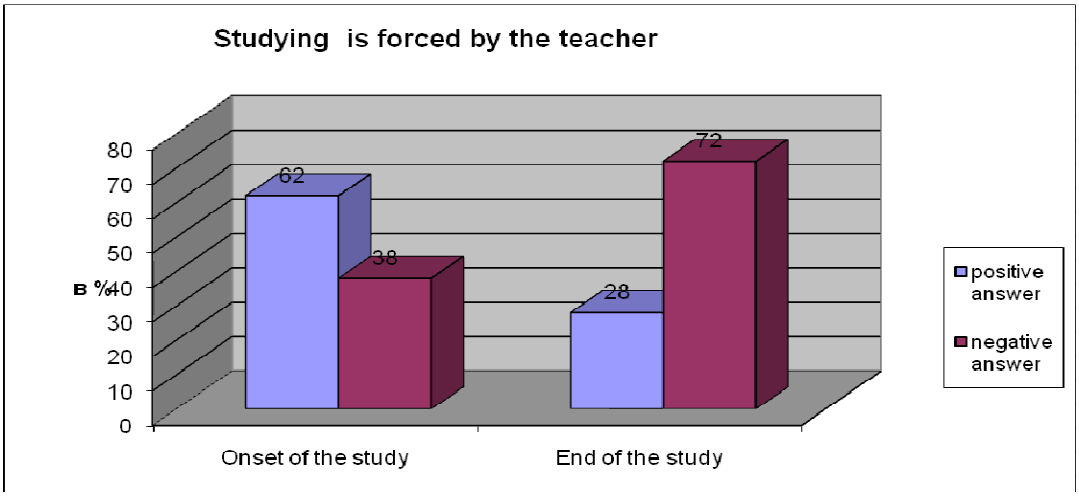

Figure № 5. Results from the test of students' educational motivation – factor III

These results correspond to a different view of the design of the learning environment; another place for the teacher in the school in order to change the motivation towards the subject during the study of which the exploration of problem-based education is conducted. The external manifestation of the relation (interest and motivation for excellence), reflected in the characteristics and the duration of the activity of problem-based education and its results, are successfully tested by the method of observation. Its primary goal is to find out to what extent the application of problem-based education in high school affects the students' attitude towards the activities and their results and to provide an initial assessment.

The survey was designed in such a way as to reduce possible influences on the behavior and the attitudes of the informants and, as stipulated by the research goal, the method of analysis of students' attitudes and proclivities in the particular moment of the educational activity is standardized observation, about which students' were not informed. The choice of indicators for monitoring is consistent with the nature of the study, using a partially modified model [2] for complex diagnostics of interest, in which the main criteria are divided according to the aspects of the activity: orientational, motivational (the emotional acceptance of the task; the emotional reaction to the cognitive content of the task; the dynamics of emotional states); operational (the degree of the emotional satisfaction; the nature of the search for a solution of the problem, the willingness to get involved; the strife for independence); regulatory (the strife to solve the task; the determination to obtain a result; the respect to that result, the behavior in overcoming difficulties; the degree of concentration).

In view of the objectives of the study, the criteria presented in it are reflected indirectly in the monitoring protocol designed for the purpose. These were then processed and the results were analyzed with respect to the following parameters: the interest, shown by the informants, their positive attitude and willingness to participate, the proclivities, participation and emotional attitude of the students during the lesson and their readiness for self-involvement in solving problems as well as their evaluation of the results achieved during the implementation of problem-based education.

The interest parameter consists in tracking students' interests through observation in the course of problem-based education. The dynamics of this interest in the experimental group is presented in Figure № 6, which shows a clear tendency towards increasing the interest and its adaptation.

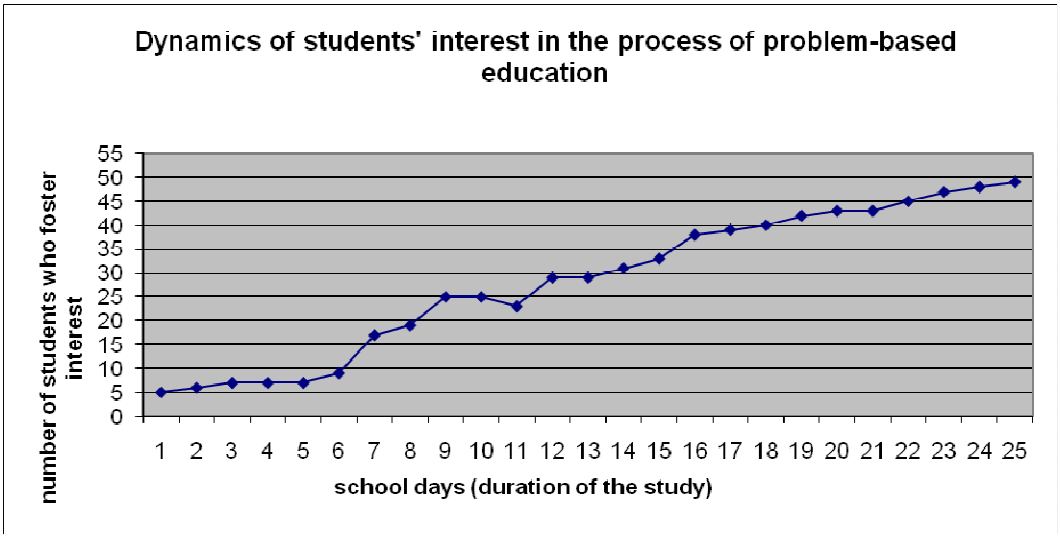

Figure № 6. Dynamics of the interest

Summarily, based on the analysis of teachers' observations and the conclusions drawn as a result, there is a noticeably growing interest in problem-based education with more than half of the students showing a strong interest in their performance. This suggests that, when implemented, this type of education increases the number of students who are actively involved in the activity and enhances their interest. Thus, students appear to be much more independent in the academic activities and generally show a positive attitude towards these activities and their results.

At the beginning of the study, students have a preference for well-structured problems because they feel insecure as to whether they will be able to successfully participate in problem-based education. Arguably, solving problems of this type is predetermined by declarative rather than by procedural knowledge, hinders the transfer of knowledge from one cognitive situation to another. In other words, these problems aid the development of skills that can be generally applied to similar problems that do not require creative solutions and do not have prominent situational character [9, 12].

After ten weeks of training, a change is to be detected in the preferences of the majority of students. They tend to prefer partially structured problems. Although these require more knowledge (not only declarative, but also procedural), analytical and presentation skills, they give students the opportunity to find alternative solutions or to propose their own strategies.

Very few students, only 10% at the end of the study, prefer ill-structured problems, which indicates that further action is needed in the organization of the educational environment so as to provoke this preference. This is made possible by the fact that ill-structured problems allow the transfer of knowledge and skills to new situations (the possibility for formation and development of transversal competences and skills) and enhance students' opportunities to solve the problem (the understanding of the system of alternatives). This in turn develops their skills for argumentation (with the possibility of constructing various models of the problem and their exploration, the formulation of hypotheses and their testing). Additionally, solving such problems improves the cognitive and meta-cognitive skills of students, because these require abstract reasoning and cognitive flexibility. All these promote the following educational results: 1) the formation and development of transversal (portable) competencies related not so much to the function of knowledge but to the intentions of the participants (their style of learning) - an expected result of the training phase of the high school educational level and a basis for the cultivation of all other key skills, special abilities and competencies; 2) a more thorough control of the learning process through the systematic and purposeful application of problem-based education; 3) design of an educational environment that guarantees the formation and development of self-reliability and skills for lifelong learning stimulated by a search for solving and defining cognitive problems.

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