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Contemporary Pedagogical Approaches for Developing Higher Level Thinking on Science Classes

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Abstract

The school is the mirror of a society. To create and develop good education means to realize objectives that would reflect its sense. In current education, the hierarchy of values that should be set and implemented is asymmetrically positioned. In successful school, the student should become the meaning and the purpose of the content that will introduce him/her into the world of competition and competence in order to enable successful communication with it. How can a teaching lesson become a workshop in which new ideas, creative solutions, new forms of research and new knowledge are being undercrossed?!

The research that has been done in this paper aims to investigate the introduction of practical teaching and application of reforms in teaching biology in the six primary urban schools in Stip, R. Macedonia. Data were collected from semi-structured interviews made with 11 experienced teachers of biology and were analyzed their class planes. The results showed that teachers occasionally introduced a small number of enhanced instructional strategies that explicitly match the formal curriculum in their classes, such as: presenting, analyzing and generalizing experimental results from practical teaching of biology in various forms. However, teachers have used fewer strategies that target encouraging higher level thinking, such as to induce students to ask questions or to learn about problem solving strategies used during lessons. Differences were identified between teachers regarding the use of rich teaching strategies during lessons, and their beliefs about the abilities of students to develop the ability to think at a higher level.

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Keywords: contemporary, teaching biology, teaching strategies, higher level thinking

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1. Introduction to the research problem

In order to discuss the issue related to the current context in which modern education has been affirmed and built, firstly the identification of the factors that determine the essence of the integration of young people in society and their role in creating change in it should be determined.

Very often it is said that the school is a mirror of society. And it is not just an empty phrase aiming to create and develop modern education, because to create and develop modern education is to realize goals that will reflect the social meaning and the vision of development.

In our schools the student, with all his/her potential, is treated as the meaning and the purpose of curriculum content, instead of being the subject who will actively participate in the awakening and development of their own creative minds, critical thought, public speech, or more specifically in the continuous creation of lasting cultural values and life in general.

The declared fundamental goals of education sounded nice in the distant 1997 on the Paris International Conference of UNESCO and are still acceptable today. They completely refer to the student who needs to learn how to study, to work, to live, and to live with others. But at the current moment as well it cannot be said that they have been accomplished successfully enough.

Despite intensive reforms in the education sector and criticism from those who, one way or another, are interested in the education of children and young adults (parents, teachers, students, politicians, businessmen ...) are still looking for a model that will enable school to approach students.

In this search, the attitudes and knowledge of science and practice that the teacher is the key factor and the carrier of changes in the school are quite clear. But at the same time, unambiguous and public criticism by teachers is directed towards the rigid curriculum, inconsistencies of the measures to evaluate the quality of teacher work, suspension of pedagogical autonomy by promoting strict didactic-methodical models through various training that only requires teachers to work rather than to be instructed in the direction - why are promoted models helpful, which the educational benefits of the same education are, and, finally, the tendency to education grounded on "evidence" that often administratively occupy teachers, so instead of essentially committing to monitoring, testing and assessment, they make a written record of these. *So, instead of the declared paradigm about reflective teachers, we get teachers artisans whose work has little science, art and soul, but very much routine*.

Education is a complex, subtle and long-term process, and that is way it is difficult to quantify precisely which factor, at what time and to what extent influences the overall development of the individual, so quantification is not sufficient and it is not a priority.

In education, the routine is a factor that negatively affects the quality of the "product" (student development). Systematically seen, feedback information and planning are key tools for increasing the predictive power of the teacher in connection with his/her decisions about pattern of work in the classroom and we have to practice these, but the problem is how to win over our children and young people to become partners in their education for a happy and fruitful life, learn how to reaffirm habits and motivation for the development of the spirit.

Our extensive hands-on experience and scientific research / teaching gives us the right to say that lectures must be set up as a workshop in which new and diverse ideas, creative solutions, new forms of research and new knowledge will crosswise. Teaching classes must be the main field in which the teacher will show his/her skills and commitment through the intersection of knowledge, skills and qualitative personal features.

The global aim of primary education in the Republic of Macedonia is to enable students to adopt a system of knowledge and skills for independent, effective, and creative activity in the social and natural environment. (Concept of the nine-year primary education). According to this global aim outlined in the Concept for the nine-year primary education in the Republic of Macedonia over natural sciences which are taught according to the curriculum in Biology, Chemistry and Physics (5, 6, 7, 8 and 9 grade), it is necessary to achieve

the objectives that mostly refer to encouraging students' intellectual competence, such as independent learning, problem solving, decision making and critical thinking.

The achievement of these objectives undoubtedly requires not only the acquisition of knowledge related to the content that is taught, but also the development of skills and learning skills that are necessary for a variety of roles (partner, creator, leader, and researcher). Teachers, especially those who teach subjects of natural sciences, will often say that the content and timeframe (as per the curriculum) do not allow us to pay attention to the development of competences needed for specific roles, not taking into account the fact that the choice of methodical-didactic approaches are essential for the realization of these objectives, and that the diversity of methodical-didactic approach offers the possibility of realization of a hidden curriculum which actually gives support to specific goals of science education.

The Republic of Macedonia has made significant efforts to promote the professional development of teachers of natural sciences, such as biology, chemistry and physics. However, relatively little has been researched about their beliefs and practices aimed at encouraging and developing thinking skills in students and to what extent they are committed to this goal. In this context, through this research we tried to answer the question - Do our biology teachers in their teaching practice promote higher levels of students' thinking, and what are their opinions on the methodical approaches aimed towards this goal?

2. Literature review

In science there is a consensus that teaching natural sciences must move from traditional to teaching based on the principles of constructivism. Schraw, Crippen and Hartlely (2006) emphasized the importance of enhancing the capability of knowledge among students and mentioned six strategic areas essential to achieving this goal: a) research-based learning; b) the role of collaborative support; c) strategic guidance improving thinking for problem solving and critical thinking; d) strategies that will help students to construct mental models and to experience conceptual change; f) application of technology; g) the impact of the beliefs of students and teachers. Although these guidelines, in modified variants, are declaratively accepted by teachers in our schools, yet it cannot be said that they are properly, purposefully and systematically applied. The reasons should probably be looked for in the inconsistency in the application of proven methodical models, when teachers implement the curriculum. Swartz and Parks (1994) suggest that, when practiced instructional strategies for teaching and learning in order to encourage higher levels of thinking, students should be systematically guided in the strategy itself. They offer 4 basic components that should be included in the design of teaching strategies for solving problems in science classes:

1) explicit introduction (Introduction) of students to the strategy of opinion in the context of teaching of a particular subject;
2) active involvement of students in the proposed strategy;
3) review/reflection upon the strategy once you acquire some experience in using it;
4) transferring, which means showing students how a particular strategy can be used in other similar situations.

Furthermore, it has been proved that the ability of teachers to plan curriculum work reflects on the ability of teachers to improve teaching in order to encourage students' higher cognitive process during class. (Leou, 2006). However, it should always be taken into account that discrepancy may appear between teacher's practices and plans. Dancy and Henderson (2007) noted that teachers may have a very progressive attitude towards education, but in practice they use conservative teaching methods. Such a situation can occur as a result of various factors such as the lack of content, lack of teacher pedagogical knowledge, difficulties in adapting to changes, pressures at school.

Dancy and Henderson (2007) have a holistic view of the problems associated with the introduction of modern teaching in schools. In the spirit of constructivism, they offer a very explicit two-part system to promote modern education in the field of natural sciences: the first part refers to educational practices, i.e., teachers'

pedagogical approaches related to: interactivity, deciding about the teaching method, sources of knowledge, student achievement, ways of learning, motivation, assessment, content, instruction concept and solving problems. In this context, they consider that there are key differences between pedagogical approaches (practices) of traditional and modern teachers. The second section deals with the concepts of teachers, i.e. attitudes, goals and other mental behavior related to education in the field of natural sciences. This section also refers to the views and attitudes of the teacher toward: 1) teaching, 2) expertise, 3) knowledge 4) nature of science, 5) role of the school, 6) students, 7) role of the teacher, 8) variety 9) intended outcome, and 10) science education.

Another problem that is seriously analyzed by science is associated with the applicant's response to questions such as: what constitutes good thinking or how to encourage students to think specifically of science classes (Beyer, 1988; Costa, 1985; Glaser, 1984; Pogrow, 1988; Sternberg, 1987; Zohar, 1999, 2004a; Zohar and Dori, 2003). Some researchers Zoller (1997), and Zohar and Dori (2003) attempted to describe the higher-level thinking and suggested explicit examples with patterns of thinking according to which these types of thinking are characterized: non algorithmic, complexity, production of multiple solutions to a problem, applicability, more criteria and common uncertainty. All these features point to the possibility of identification of critical thinking with higher levels of thinking which mainly include capabilities for analysis, synthesis and evaluation. Temple, Meredith and Style (Temple, Meredith and Steele, 1997, 1998) define critical thinking as a complex cognitive process by which the ideas and their implications are reviewed with some scepticism, the conflicting views are carefully weighed, question are systematically asked and answers sought, and finally, opinions are based or formed on sound arguments**.**

In the Republic of Macedonia, although the objectives of the national curricula are designed according to Bloom's taxonomy of educational objectives and they provide requirements for the development of higher levels of thinking, and teachers are required to specify the goals of teaching classes and to determine the anticipated outcomes; among teachers arguments/disputes about modern methodical approaches to achieve them still appear. (State syllabus for primary education).

Pursuant to confirmations that teachers' beliefs and attitudes play an important role in the educational process, with this micro research we tried to discover the following: What are the plans, teachers' ideas about contemporary teaching that prefer the creation of conditions for the development of students' higher thinking process? Which methods of teaching and learning are really / actually used in biology classes, taking into account traditional and modern pedagogical approaches?

The research will contribute to the detection of the educational needs of primary school biology teachers for professional development in the field of active classes with a special focus on the instructions that tend to promote higher cognitive processes in the classroom.

3. Empirical research approach

The subject of this research are the attitudes and opinions of biology teachers, regarding the application of methods / techniques / strategies that encourage higher levels of thinking of students and their implication on the development of students' higher levels of thinking in order to study the teaching practices in biology, regarding the application of these methodical approaches to detect the needs of teachers for continuing education in this direction.

The research is grounded on the principles of the descriptive-analytical method. Data were collected using semi-structured individual interviews, for which a special protocol for interviewing was prepared. The interview is a research technique that we believed is most appropriate for achieving the objectives of this research, because it can provide a rich source of data that provide information not only for the views and opinions of the respondents about a specific problem, but it also provides arguments for them. An analysis of one-year teachers' pedagogical records (plans for delivering lessons) was performed in order to compare the data obtained through interviews and planned teaching methods / techniques / strategies. Data processing is predominantly qualitative.

The survey included 11 biology teachers (eight female and three male, with over ten years of experience in the teaching profession) from six elementary schools located in the territory of the municipality of Stip (urban environment), the Republic of Macedonia. In terms of socio-economic status of students, schools have a heterogeneous character, but they all teach according to unified state programs for biology and are subject to the same tests for external assessment. The sample is intended with respect to the subject the teachers teach and work experience. The selected teachers are considered successful in their environment. Huberman (1989) describes teachers with this background as teachers with "divergent period" in their professional development and they are characterized as follows: "Some teachers have described this as a period of experimentation and activism in which they develop their syllabi, trying new approaches to teaching and confront institutional barriers. While others see it as a period of doubt in yourself and questioning. "

We are aware of the limitations of this study due to the small number of respondents. Yet we see the advantage in focusing on the study of teachers in a specific discipline, in a relatively well-established field such as biology and from schools located in a small geographical area. This allows concentrating the discussion on teachers' knowledge and attitudes with the same professional background. Accordingly, we expect to reduce the impact of factors related to discipline differences, cultural and material conditions in which teachers work and professional development opportunities. It is important to note that teachers were interviewed about their daily practice and analysis of their daily planning, so as to render a comparison between the data obtained from interviews and what they have in a written plan. We think that those are the most natural conditions in which this research can be realized. As professors at the Faculty of Educational Sciences and mentors of students who performed pedagogical practice in these schools with teachers of the sample, we have developed trust and professional relations based on the principles of cooperation. They do not feel they will be judged or criticized. Hence, we believe that the context of the study described above contributes to the validity of the outcome.

3.1. Course of research

Phase 1: Analysis of pedagogical documentation - a year of operational planning for the teaching class.
Phase II: semi - structural interview. Each individual interview lasted about 60 minutes, although with a few teachers we talked longer because of their concern about certain practical problems.

The course of an interview: 1. Introduction - creating a relaxed atmosphere by explaining the interviewee that the research is aimed at studying the biology teaching practice in order to promote it by collecting opinions of her direct executors and does not intend in any way to evaluate teachers . 2. Presentation and discussion of /according to the list of 20 instructional strategies (selected from the current didactic-methodical literature, from the materials used in the continuous training of teachers in the Republic of Macedonia, and especially those which were included in lessons planning). (See Table 1.) This was in some way part of the introduction to the interview. Example: To what extent/degree (how often?) does the teacher use a specific strategy in class? What are the pros and cons? Where have they learned the strategy? The conversation is not strongly related to our research framework, but it is developed in different directions depending on the interests and preferences of the teacher. Similarly, compared to the study of Henderson and Dancy (2005), participants were asked about their teaching goals, current and past teaching experiences, or attempts to make changes.

The fact that the research is based on what the teachers say, what they have planned, and that it is carried out outside the classroom, presents a limitation on the one hand, but on the other hand has the advantage because the interviewees are not judged, they are not under pressure and can freely talk about their way of teaching and honestly express their views. We got the impression that this approach has encouraged teachers to talk about their successes and their failures, rather than trying to present them in the best light.

Bearing in mind the fact that there were two researchers, one of us recorded the data in the interview protocol for each individual teacher. In the research process we conveyed inductive analysis, and the topics and

categories provided by the interview protocol were supplemented according to the information that we received. In order to verify the data, at the end of each interview, together with interviewee, the notes were reread and the protocol revised (Strauss, 1987).

3.2. Analysis and discussion of results

Phase I: Analysis of pedagogical documentation - a year of operational planning for the teaching class.

Analysis of the one-year planning for a teaching class of teachers from the sample reveals that teachers plan instruction that is based on the application of strategies that encourage higher levels of thinking. 13 strategies / techniques are recognized in their operational plans (they are listed below in Table 1 under numbers from 1 to 13). Most frequent strategies are under numbers 1, 2, 3, 6) and are provided to be applied 5 to 7 times during the school year in one class. According to planning, these approaches are mainly realized through frontal and individual teaching forms. Application of strategies under number 1, 2, 3, 6 was planned by all the teachers from the sample.

Table 1. Strategies / methods / techniques practiced in biology teaching
(Individual, frontal and group / team work)

1.	Presenting data in various forms (graphs, tables)
2.	Systematic orientation of students to justify their solutions to specific problems or their decisions (reasoning)
3.	Learning through solving problems
4.	Generalizations based on experimental results
5.	Analysis of processes/situations and confrontation
6.	Strategies for the development of divergent thinking (grapes, prism, ...)
7.	Integrating different solutions or ideas
8.	Transfer of knowledge (biology with other scientific fields)
9.	Predicting the results of an experiment or theoretical solution of the problem and providing justification for it
10.	Require students to make a reflection of the learning process
11.	Request for application of concepts in different situations - application of knowledge
12.	Require students to state the difficulties encountered and explain how they mastered them
13.	Learning through projects
14.	Creating situations in which students present contradictory views and try to convince each other
15.	Selfasking – development of metacognition
16.	Require students to formulate questions
17.	Using maps with concepts
18.	Involving students in determining the criteria for evaluation

Phase II: Structural interview

Through interviews we first received information on the frequency, type and experience of applied methods / techniques / strategies (offered 18) in biology classes that encourage and develop higher level thinking activities in students. (Do they practice at least one of the offered strategies in every teaching class; if not, how often do they do it (rarely, sometimes, or often)? Do they use some other strategies?) This was just an introduction to the discussion that developed in different directions according to the interests and

affinities of each teacher, which indicated that they want to discuss this issue. (Discussions are explained further in the paper).

All teachers have found that sometimes they apply some of the offered strategies, but that they do not do that at every teaching class. As main reasons for this the following were mentioned: lack of time during teaching classes, uneconomical strategies for extensive curriculum, external evaluation of the students that is exercised in accordance with strictly defined indicators.

As cost efficient strategies in terms of time and frequency of application, they pointed strategies under ordinal numbers: 1, 2, 4, 5, 6, and 9 (see Table 1). The essential tool for this is setting of tasks and issues according to Bloom's taxonomy mainly by frontal and individual work with students (teaching papers, tests of knowledge, graphic organizers).

What do teachers think about the benefits of the application of modern methods of learning how to develop higher levels of thinking? This was another question around which the interview was carried out. Generalization of the concepts of biology based on the experimental results obtained at the teaching class, is an approach by which teachers provide the deepest understanding of the content, enable the development of analysis and synthesis skills, and the knowledge is much more lasting. However, teachers recognized that the application of laboratory experiments in teaching biology is relatively rare, as opposed to what the nature of the subject demands, due to lack of material resources, time, and most engagement for the preparation it by teachers.

Study through solving problems, by most teachers (8), was referred to as an approach that is useful for the development of logical thinking, and discovering causal relations. It is important to emphasize that teachers are conscious that learning through solving problems gives results only when students are consistently and systematically instructed in the process of problem solving, but they acknowledged that not always in organizing this type of teaching, they insist that the students pass through the stages of getting to the solution of the problem; hence the results are unsatisfactory.

When it comes to the application of cooperative learning techniques and teamwork, all teachers said they rarely exercise them. They are not theoretically prepared enough and are not aware of the benefits of thereof and believe that this type of learning often boils down to the work of individual students who mostly belong to the group of successful and those less successful, hiding behind the work of others. When we directed our conversation to the disclosure of teachers' practices with regard to the formation of groups or teams, as well as on the role of the teacher in assigning tasks to individual students, we found that this phase of organizing team learning is performed by teachers inadequately, mainly formally. Teachers also hardly give importance to the development of social and emotional competencies among students and meeting the needs for self-affirmation. Synthesized, the views from the interviews with teachers can be boiled down to the following: "The social and emotional development of students is important, but we do not have the time to pay special attention to these."

Rarely applied strategies are: learning through projects (13) Self-questioning (15) and asking questions (16), Using maps with concepts (17), Involving students in determining the criteria for evaluation (18).

According to all teachers, learning through projects is ineffective and it is inefficient as a teaching strategy, but as an approach it can be applied in extracurricular activities. Teachers in our sample hardly use the technique–self-questioning even though half of them have undergone training to use it. Blank (2000) suggests a successful model of critical thinking Metacognitive Learning Cycle (MLC), which emphasizes the systematically use of discussions and reflections in order to promote explicit metacognitive understanding and solving problems. Also, teachers (only 3 - rarely) rarely put students in a situation where they will ask questions that relate to the content taught. Those three who tried to do so concluded that they are not trained to ask questions.

Teachers rarely insist on the reflection of the learning process through which students have passed, regardless of the fact which strategy / method or technique they used. Because of these reasons, they could not give an opinion on the benefits of this approach. As a justification for this situation the problem of lack of time was again highlighted, due to the large volume of administering evidence about student achievement and progress. Only one teacher believed that the development of higher levels of thinking - enabling students to analyse, synthesize, generalize, and evaluate should be accompanied by giving enough time by the teacher for

thinking. He said: "I do not allow students to respond quickly because if you let them do that, they will not have time to think. First you give them time to reflect: I do not accept any response in the first 2 minutes, for example ... the answer must be the result of a process of reflection, and thinking requires time. "(S.T)

Specific/concrete strategies that enable the development of higher levels of thinking among three teachers are only organizational methods which do not differ much from the methodical and didactic approaches that are practiced in "traditional" teaching: "What is offered to us at the methodical training is mainly known and practiced by us, perhaps in another form." (RS, L. R.., M. S.). Still, in further discussion, these teachers acknowledged that when they plan the lectures, they usually do that as a routine and do not sufficiently reflect on the relationship between the objectives, outcomes and ways of monitoring and evaluation of the realization of the objectives. When these teachers were asked why they chose to use the data presented in charts and tables they could not give an adequate response.

Several comments with which teachers justify traditional approaches to teaching: "It is easier to develop the opinion of the biology class because you have the tools to do this. What are the tools for CONSIDERATION? You have a collection of laws and rules ... you use these to solve the problem or conflict. "(A. T)."The current situation is that, if you stop lecturing, you lose control over the class ... students begin to speak among themselves." (L. R). "If I had a class which is quiet, I could have more discussion. In our school the discipline is a problem. In a class in which you have problems with discipline, everything you can do is to teach technically. "(A. M.)

"Because students lack a culture of discipline, it is difficult to realize the work in groups / teams. They begin to shout to one another, so that it turns into a waste of time." (MA) Three teachers in particular have emphasized that they feel insecure when using complex strategies of teaching: "I do not want discussions ... They often turn into a pointless conversation and it is difficult to deal with it."

Certainly the teachers' beliefs about the educational power of specific methodical approaches in teaching are the most important factors in any educational reform (Kagan, 1992; Pajares, 1992). The discussion with teachers indicated that respondents were going towards two extremes in terms of their assessment of the potential of students to gain the ability to think at a higher level and the impact of teachers. At one end were 4 (four) "pessimistic" teachers who said things such as: "Some students, despite my efforts, fail." "A person is born as it is ...maybe it is possible to teach him/her to think a little but not too much." At the other end 5 (five) teachers were interviewed, who had great faith in their students, but also in the power of modern teaching: "If you continue to speak 'you must make a decision', 'decide on your own', think why? Look for information elsewhere... ask yourself a question what you want to learn. You have a similar example.... ", they become aware of their ability to think and learn.

Conclusion

Although the school is in permanent crisis from its very beginning, it should finally be realized that the society is in crisis, and the condition of the school is only its logical consequence. It seems that modern education is still awaiting its realization. In our country, at least with reforms that will mean providing a natural environment in schools (some schools), quality and reduced curricula, creative freedom to create new ways of learning, intensive socialization, respect for family values that will keep it in existence, that will improve the school and promote and develop the society and the abolition of formalism and routine work, we can make a step forward, a step into the future. In such circumstances we will be sure we are creating generations for whom education is a unique and powerful intellectual challenge, not a risk that can take away the most valuable resource of our development – the children.

This research aimed to examine the beliefs of biology teachers in connection with the introduction of the modern way of teaching. Although all participants in this study were experienced teachers and biology is considered a well-established subject in Macedonian schools, differences between teachers in terms of: frequency of use of strategies that promote higher levels of thinking of the students were identified; their confidence when

applying these strategies; their beliefs about the abilities of their students to develop higher level thinking; their belief in the educational benefits for students from their application.

To get closer to the introduction of modern science teaching, we accept Pogrow's approach (1996) that changes in education require very specific, systematic and structured methodologies with additional teaching resources. But we remain of the view that the teacher, with his/her dedication, is the key factor that determines the quality of education.

The introduction of elements of the constructivist pedagogy combined with specific steps aimed at encouraging higher level thinking should be a realistic goal to which teachers should aspire. This research showed that they rarely insist on reflection of the learning process through which the students passed and rarely use self-asking. Blank (2000) proposes a successful model of critical thinking *Metacognitive Learning Cycle* (MLC), which emphasizes systematic usage of discussions and reflections aiming at promoting explicit meta-cognitive understanding and problem solving.

In order to encourage and develop students' higher levels of thinking through teaching biology, teachers should apply the already learned strategies of teaching and learning consistently in terms of: steps in the performance of the strategies themselves; established instructional objectives and expected results; encouraging students to maintain the process of learning and students' becoming aware of personal learning benefits of such approaches to learning.

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