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WHERE ARE THE STUDENTS ON THE PATH BETWEEN BLOOM'S TAXONOMY AND THE CRITICAL THINKING

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Abstract. This text contains short explanations which, in a simple manner, should bring us closer to the meaning of the concept of critical thinking, as well as some indicators which make us acquainted with the level of presence of the critical thinking among students. Explanation of critical thinking is given through distinction of mental processes that help in the building of the Bloom's taxonomy, which is also briefly explained. The representation of critical thinking among students is tested with an exam of five tasks which greatly differ in concept from tasks which students are used to solve. Students could not solve such tasks unless they have certain qualities necessary for the development of critical thinking. Presented results from the conducted test should not be considered as true measurement of representation of critical thinking among students, but they undoubtedly indicate the lack of it.

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1. INTRODUCTION

Education that produces cadre based on educational aims outlined in the period of industrial revolution does not give results any more. The economic progress demands people that are capable, from the jungle of information, to find and analyse only the needed data and from them to make conclusions which they themselves will use to come to a solution to problems that they come across to. However, education that aims to provide students with lots of information can not contribute to development of such skills. The aims of modern education should be directed towards development of mental abilities which are hierarchically ordered in the Bloom's taxonomy, and especially towards development of high order thinking skills, where the concept of critical thinking lies. In this text, there are given information gained by testing of a small number of students, and from which we can get general picture on which level of Bloom's taxonomy the thinking skills of students are, and to what extent their thinking has characteristics that are typical for critical thinking. For a simpler perception of the point of the test results, at the beginning, the basics of the Bloom's taxonomy and critical thinking are shortly explained.

2. BLOOM'S TAXONOMY AND CRITICAL THINKING

Coming to a conclusion that the Earth spins around the Sun, besides the fact that a superficial observation of the phenomenon may bring us to a contrary conclusion, is just one example that unequivocally confirms the power of thinking skills. Most knowledge, on which contemporary people rely, comes from the information gained through the process of education. If, at school, they did not give us and explain the information that in fact the Earth spins around the Sun, probably most of us would believe just the opposite. However, memorising the information that the Earth spins around the Sun and proving that the Earth spins around the Sun does not require the same level of thinking skills.

Thinking skills are divided in two groups:

- Low order thinking skills (LOTS) – this group contains skills such as acquiring new knowledge, its understanding and usage in certain situation;
- High order thinking skills (HOTS) – this group contains skills such as analysis, evaluation and creation.

In Macedonia, during the educational process, commonly the LOTS are stimulated, while the HOTS are almost totally neglected. At present, the fund of knowledge is so big that it is impossible to remember all the information that is served to us during education, or to insert them in teaching programs, and on the other hand, its usage in working tasks is inevitable. The conclusion is that the aims of contemporary education, which are directed to adoption and usage of information, have to be altered and redirected to development of thinking skills that will help students to discover, evaluate and use information on their own in various contexts. This kind of classification of educational aims, for the first time, was made in 1956 by Benjamin Bloom. It is known as "Bloom's taxonomy" and it is a complex model of classification of thinking which encompasses three domains: cognitive, that covers knowing and understanding, affective, which covers behavior, emotions and personal attitudes, and psychomotor, that deals with the connection between physical activity and mental processes. In this text, we will deal only with the cognitive domain of the taxonomy which, over time, was changed and altered, and the last revised version was published in 2001 and it contains six levels which are hierarchically arranged in a pyramid shown on Fig. 1.

The levels of the taxonomy are growingly arranged, and the first three levels, remembering, understanding and applying, correspond to LOTS, while the next three levels, analysing, evaluating and creating, correspond to HOTS. The levels of the taxonomy observe the logical development of thought where no one can cross from the level of remembering to the level of applying without previously overcoming the level of understanding. However, there is an opinion that the levels of HOTS should not be placed in vertical hierarchy because there is no need for constant following of the given order, and that initiates the suggestion for them to be placed horizontally.

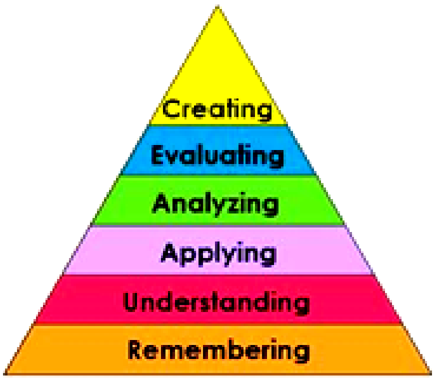


Fig. 1: Cognitive domain of Bloom's taxonomy

Because with the Bloom's taxonomy we can determine the level of thinking that a student achieves, it is actively involved in the process of grading. Each level of the taxonomy is accompanied with series of verbs that indicate the activity specific for a certain level. For example, if a student can only list some information, then he or she is on level of remembering. If the student can classify them, then he/she is on level of understanding. If the student uses the information to solve a task, he/she is on level of applying. But if the student on his/her own finds information and uses it to make a hypothesis for which he/she creates an answer that expresses its true value, then he/she reaches the levels of analysing, evaluating and creating. This kind of student's skills shows developed HOTS which are excellent basics for developing of a special kind of thinking, called critical thinking.

Although the critical thinking is not clearly defined, there are certain skills which are pointed out, that a person should have, so that we can say he/she managed to develop critical thinking, or that he/she strives towards developing of critical thinking. Critical thinking is an active process, which means that it cannot be developed by listening to information and its memorizing, but it is a product of processes through which intellectual skills, such as analyzing, comparing, validation and synthesis, develop. At the basis of these processes, and by that at the basis of critical thinking, lies the ability of devising and asking essential questions that are clearly and precisely formulated, as well as detailed analysis of obtained answers which can be incomplete and ambiguous. Insufficient analysis of answers can bring us to a situation of making a conclusion that can unjustifiably put down or confirm our hypothesis. Anyway, if some information contains ambiguity or uncertainty, we should not discard it immediately, but we should always consider its imperfection.

Other important characteristic of critical thinking is ability of distinguishing observation from conclusion. Inability of such distinguishing can be noticed at students who, while making experiments, usually see what they want to see, they insufficiently process the information obtained from the observation, and present it as conclusion. For example, if a man, dressed in white coat, walks in a classroom, most of the students, based on observation, would say that the man is a doctor and they will present that information as a conclusion, although the man in a white coat could be a butcher, cook or baker. Coming to a conclusion based on observation is a complex process which includes making a hypothesis and its accepting or dismissing according to an analysis of the phenomenon and obtained results. Ability of application of a general rule to a specific case, or making a conclusion from a specific case a general rule is a proof of strongly developed sense for causal links, as well as ability for deductive and inductive concluding, which are one of the basic characteristics of critical thinking, and which help us determine whether the conclusion we made can be presented as a generalization or not. Students are often asked questions that do not encourage deep thinking, by which, based on their knowledge, would visualise certain phenomenon, and by abstract changing of conditions would come to a conclusion about the consequences that would come out of that change. Testing of conclusions from hypothetical thinking means that the student is able by himself to test his assumptions that are made on the basis of his own knowledge, by which he actually makes self-evaluation, validates his knowledge and abilities, discovers whether there is need for correction or possibility of upgrading of already gained knowledge, by which he develops constancy of his own thought and gains self-confidence. By developing the mentioned abilities, we can say that a certain cycle of critical thinking is closed, when a student already becomes able to determine which processes are the most appropriate in certain circumstances, he asks himself and finds answers on his own.

3. CRITICAL THINKING IN TEACHING PHYSICS

Physics, in the process of education in Macedonia, starts to be learnt in the seventh grade when students are at the age of 12. The reason for this is that, according to psychological research, exactly at this age thinking becomes more abstract, and this is a characteristic necessary for comprehension of certain phenomena. After finishing the course of physics at primary school, it is not expected that the students will have specific complex knowledge of physics, but they should be familiar with basic concepts of physics and natural sciences in general and start practicing more demanding mental abilities, actually start perceiving causal links in natural phenomena. These aims can be a foundation of development of critical thinking among students. In order to get a specific idea about the presence of critical thinking among students by the end of the eighth grade, 45 students were offered to take a test containing five tasks which solving depends on having certain abilities characteristic for critical thinking.

The first task given in the test aimed to determine whether students will succeed to notice and use all the information presented in the task, in order for them to solve it successfully.

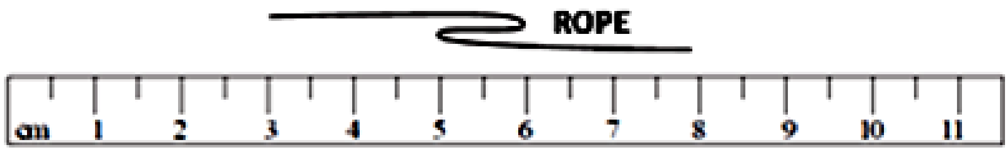
Task 1: *Is the calculation correct?*

$1 = 100¢
= 10¢ x 10¢
= $(1/10) x $(1/10)
= $(1/100)
= 1¢.

Before they begin solving the task, although it was confirmed that most of the students already are familiar with the symbols used in the task and their meaning, the symbols were explained in short. The results of the solved tasks showed that 73% of the students answered that the calculation is correct, contrary to 27% of the students who answered that it is not correct. In addition, only one student gave correct answer why the calculation is incorrect. Besides the fact that all the students know that 1$ is not the same as 1¢, more of them discarded that fact in favour of the fact that the operations with the ciphers in the task are correct. When, during presentation of results, it was pointed out that 10¢ x 10¢ actually is 100¢^{2}, most of the students confirmed that they know that, but they have not thought about it at all. It is obvious that the students failed to gather all the information given to them in the task. They did not take into consideration the operations with measurement units, although, during the course, the importance of measurement units in numerical tasks in physics was often highlighted.

The rest four tasks from the test were divided in two groups of two tasks. The tasks from the first group (control) had their cause to check whether the students have basic theoretical knowledge about physical phenomena, which on the other hand are dealt with in the second group of tasks. The first control task asks students to determine length of a building shown on picture, where a car is also shown which length is given. Results from this task confirmed that students face no problems measuring the length by comparison of two things. As a pair to this task, there is a second one where again students' ability to compare is being tested, actually length should be measured once more, but this time in a different situation. The task is given in following manner:

Task 3: *If we straighten the rope, which of the given lengths is closest to its length?*



a) 5cm b) 6cm c) 7cm d) 8cm

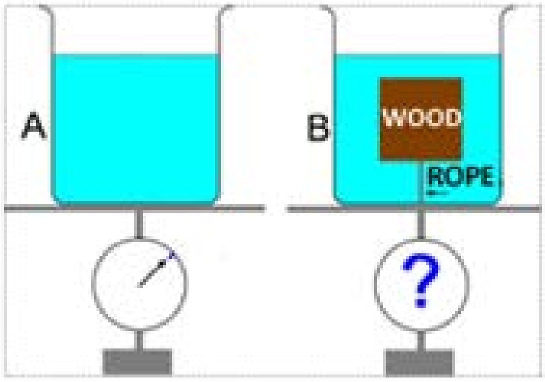
My expectations were that this task will be solved by all students. However, the results did not turn up as expected. Almost half of the students answered this question wrongly. Here are some of the students' answers:

- The rope is now 5cm long and the folded part is 1cm long, so if we straighten the rope, it will be 6cm long.
- It will be 8cm long because when we straighten it, it will start at 0cm.
- One of the students does not give an explanation, but gives the solution in a form of mathematical equation: 3+1+2=6.

These answers do not mean that the students do not know how to measure with a ruler, but show that it is possible they have serious problem which can be seen when they cannot apply their own knowledge in new and unusual situations, or in situations that are not thought at school. Again, these abilities are vital components of critical thinking.

The second control task tests students whether they understand the relationship between volume, density and mass of a body. Results of this task show that almost all students successfully mastered this concept. As a pair to this task, there is the following task given:

Task 5: *Two identical containers shown on the picture below are filled with water to the same height, but in one of them there is a wooden block attached to the bottom of the container. Which container weighs more? Do both containers have identical weight?*



Even 53% of the students answered that the container with the wooden block is heavier, 25% answered that both containers have the same weight, and the rest 22 % answered that container A is heavier. Most of the students, as an explanation to the answer, say that wood has lower density. As particularly interesting thoughts, I would like to mention the following explanations to the answers:

Student 1: "Container A has higher weight because wood has such property that it always stays at the water surface, so if the wood is attached to the bottom of the container B, it will move the container upwards, as a result of which the container A will have higher weight".

Student 2: "The container B is heavier because wood has power to float on the water because it has lower density, so it does not add on weight".

I gave the same task to students who already have shown their skills in solving numerical tasks in physics at the school, regional and state competition in physics. At my surprise, most of them answered that the container B should have higher weight. However, when I faced the students with the questions "why does wood float on water surface", "what is the volume of displaced water in the second container" and "how do we calculate mass", they changed their opinion and offered detail analysis of the phenomenon and a correct answer.

4. CONCLUSION

Although the students had all the needed information to successfully complete the task, still they did not approach the phenomenon analytically and did not use their formal knowledge to synthesise answer. This small test proves nothing, but it shows that if we encourage students they can put their formal knowledge in function of analysing relatively complex problem and to find solution to it, actually to manifest thinking which is good basics for further development of

HOTS and critical thinking. Such students' performances are the thing that we need to strive to, not just for the sake of education, but also for the sake of society and physics as a science. The enormous fund of knowledge demands long time to develop cadre that will achieve a level at which they can cope with contemporary physics concepts. All this will not solve the bitter problem of cadre development, but it will surely make way to solution.

REFERENCES

[1] B. Mitrevski, O. Zajkov, „Mathematics and Science Teachers' Concept of Critical Thinking", Bulgarian Journal of Physics **38**, (2011)
[2] K. Prenton, S. Jankulovska, „Teaching and learning of the 21st century", PEP (2010)
[3] V. Vizek Vidović, V. Vlahović-Štetić, M. Rijavec, D. Miljković, „Psychology of education", Zagreb IEP (2003)
[4] A. B. Arons, „Teaching introductory physics", Prosvetno delo, Skopje (2010)