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SOME CRITICAL CONSIDERATIONS FOR TEACHING PHYSICS IN ROMANIAN HIGH SCHOOLS

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Abstract. Fewer and fewer people realize that physics has been and will be the engine of technological breakthroughs. The discoveries in physics have made and will make human life easier and more beautiful. And even so, Physics is not a discipline of study of much interest for many, due to the poor motivation of finding a stable and well-paid job. For this reason, the teaching of physics has become a real challenge for teachers. Numerous studies in the country and abroad have shown that physics is no longer a subject of study to attract students. To assess the impact of physics on students, we distributed a questionnaire to a number of 487 – 11th form science majoring students in several high schools in three Romanian counties. The students critically analyzed the questions and the answers show that they are not indifferent to the future. They expect from the Romanian high school and also from the Romanian society, at least, more attention and care for the problems they face.

Key words: assess the impact, learning outcomes, teaching strategies.

1. INTRODUCTION

Physics is a discipline of study that has not attracted and still doesn't attract students. They tend to avoid it, since it requires too much work compared to the prospective achievement in terms of career opportunities [1]. A study on a sample of 295 students, randomly selected from 9th, 10th and 11th grades, conducted in Turkey of the 2009–2010 academic years, revealed there is a negative attitude towards studying physics: 53.2% of students confirmed that "Physics lessons are boring", 67.2% of them fail their physics lessons, 58.3% of them feel helpless when doing Physics homework and Physics lessons are difficult for 34.6% of students [2]. Two samples of Romanian students, one comprising 112 of 8thgrade students and another one comprising 101 of 9th grade students were questioned during September–October 2008 and 2009 about physics' learning.

Both levels include fairly high percentages of students who dislike studying Physics: 50% of the 8th graders and 38% of the 9th graders. The time they allot to studying physics varies within the following range: not at all (25%, respectively 6%) and 2 hours (11%, respectively 7%) every week [3].

Science education experts believe that either the teachers have a weak foundation of knowledge, or they and especially the students have a poor motivation for learning physics. Then physics teaching is a complex problem in many countries [4, 5]. At least for developing countries, the universities offer in the field of physics only didactic and underpaid career opportunities. Therefore, the number of high school graduates who choose to pursue physics at a university level remains low. After the 1990s many studies have shown an alarming decline of youth interest in learning basic sciences and mathematics [6]. Some poor countries in 2004 had a very low percentage, between 5–10% of enrollment in high-profile science. In the 2000's there where only 40,000 holders of a degree in physics out of a population of 500 million inhabitants, *i.e.* a very small number compared to the real needs. In 1999 the number of physics graduates was the lowest since 1950. In Europe, the number of physics graduates decreased on average by 15% between 1998 and 2002 (–28% in Germany, Spain –16%, –14% France) [5, 6]. The interest in physics studies in Poland is rather low, there are 4 times fewer students of physics in comparison with Germany [7]. In the developed world, the students who complete a degree and go on to become physicists, usually find employment either in the university sector or in industry [4]. For example, in the USA, initial employment sectors of physics bachelor's, classes of 2006 and 2007 is shown in Fig. 1 [8, 9].

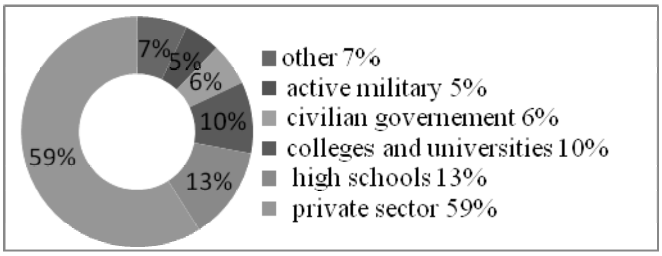

Fig. 1 – Initial employment sectors of physics bachelor's.

Fewer and fewer people realize that physics has been and will be the engine of technological advancement. The discoveries in physics have made and will make human life easier and more beautiful. Fewer and fewer people realize that the ignorance of physical phenomena can lead to accidents, for environment, for civilization and even to the entire Earth destruction (as Chernobyl – april 26, 1986, Fukushima – March 12, 2011). And even so, Physics is not a discipline of study of much interest for many students. The declining interest to study science on the one hand, and the lack of enthusiasm to take physics course in school or avoiding physics as a college major, on the other hand, has been an international problem [10]. Most physics teachers in universities and secondary schools either lack the appropriate educational background in physics or have only a tenuous hold on their conceptual understanding of physics. The specialists in the field of physics study the causes of this situation and seek remedial solutions. Recent studies show a marked improvement in student performance when interactive teaching methods are applied [5].

2. METHODOLOGY OF RESEARCH

To assess the impact of physics on Romanian students, from 23 to 26 May 2011 we distributed a questionnaire to a number of 487 – 11^{th} form science majoring students of several high schools in the cities of Bacău, Bârlad, Vaslui and Brăila. The questionnaire included a set of 14 questions to which students responded according to their own choices without being prepared in advance. The students didn't have to sign the questionnaire so that a greater degree of objectivity could be achieved. The students who participated in the questionnaires come from renowned theoretical and industrial high schools. The elected students were in the 11^{th} form, because they are potential beneficiaries of optimized teaching and learning strategies, they have already developed plans for the future and because they also have sufficient knowledge of psychology to allow them an understanding of the current problems of society. The students critically analyzed the questions and the answers show that they are not indifferent to the future. What it is most important is that they expect from the Romanian high school and also from the Romanian society, at least, more attention and care for the problems they face. The study was conducted as research for The Doctoral School of Physics. It was presented at The Summer School in the areas of physics, chemistry, mathematics and computer science – a multidisciplinary approach, July 2011, organized by the University of Bucharest. The summarized situation of responses to questions is as follows.

2.1. WHAT IS THE TYPE OF INTELLIGENCE THAT CHARACTERIZES YOU? (AS YOU LEARN PHYSICS MORE EASILY, WHICH IS YOUR CHARACTERISTIC STYLE OF LEARNING?)

The first step in the study was to find the predominant students' types of intelligence thereafter to determine the preferred students' learning styles: visual, auditory or kinesthetic [11].

As science majoring students, specialization: mathematics – computer science and natural science, they should be characterized primarily by logical-mathematical and visual-spatial intelligences, which has been confirmed in Fig. 2.

However, the highest value achieved is for the intrapersonal intelligence, which leads to the conclusion that for the surveyed students, teachers have predominantly applied traditional teaching and learning methods. For example, the work was not differentiated, there was no teamwork, the focus being on individual study. This conclusion is also confirmed by other results in some of the following questions in the questionnaire.

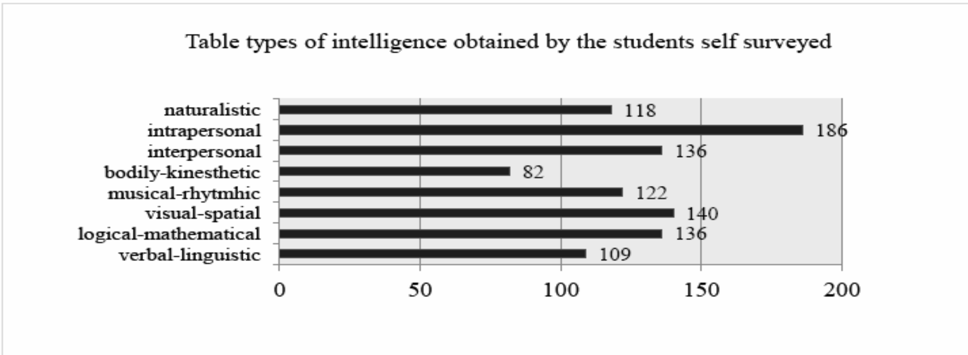

Fig. 2 – The share of characteristic intelligence types.

2.2. DO YOU THINK THAT YOUR LEARNING STYLE WAS TAKEN INTO ACCOUNT IN THE TEACHING AND LEARNING PROCESS IN PHYSICS? (DID YOU LEARN EASILY OR DID YOU HAVE TO DO ADDITIONAL WORK?)

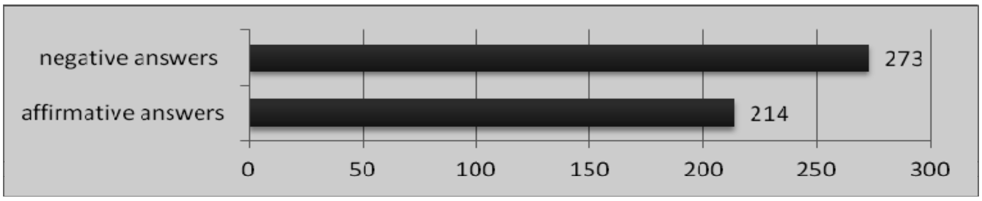

Fig. 3 – The adaptation of teaching physics to students' learning styles.

There should be selected those methods that give each student the possibility to acquire the contents and to accomplish his tasks according to his possibilities, his needs and rhythm of learning [11]. The students' answers to the questions referring to the degree of adapting teaching styles to learning styles, concluded that adapting teachers' physics teaching styles to students' learning styles is only done in 44% of the cases (Fig. 3). Although the students were not prepared in advance for the interpretation of questions, their answers show that teaching and learning of physics took place predominantly in a traditional manner (because this is the way in which each student's intellectual potential is not taken into account). On the other hand, the small difference (12%) between traditional and modern teaching and learning of physics, demonstrates either that more and more teachers of physics become aware of the need for other approaches to teaching and actually use them, or that more and more students access sources of information external to school, especially the Internet, taking into account the interpretation of the questionnaire responses to the first question. The teachers' disinterest in quality classes is also possible to have increased, leading to excessive reduction in the amount of the communicated knowledge and a "relief" in students' understanding. Excessive speed is not excluded from individual learning (as confirmed by the interpretation of the responses to the first question) by means of essays, where students copy/paste material from the Internet, a material easier to understand because it is accompanied by images, sounds, animations, which meet a wide range of students' requirements.

2.3. WHAT LEARNING METHODS HAVE THERE MAINLY BEEN APPLIED IN THE TEACHING PHYSICS PROCESS?

Nowadays, given the rapid technological evolution of society and the massive impact of the computer use, poor results in learning physics is obtained mainly because of the excessive use of traditional teaching and assessment methods, lack of school laboratories or their poor equipment, the non-use of audio-video tools or computers in teaching. Numerous pedagogical studies have shown that the traditional training has a low yield. Some of these studies state that 90% of traditional lessons lead to better outcomes only for students predominantly characterized by a learning style based on hearing and yet only a small percentage, 20–30 % of them remember less than 75% of what was presented [12]. Research in the field of memory confirms that after three days, man remembers only 83% of the received information through the visual channel, 12% through the ear channel and only 5% through other senses [13]. Solving problems is the predominant traditional approach in teaching physics. Problem solving is traditionally taught by providing examples for the student to emulate. The drawback is the students tend to emulate what they see. What they see, typically, is that after a little talk some formulas are written down from which a numerical solution is obtained by manipulation and substitution [14]. Many students are trying to memorize formulas and results. But if they do not understand the phenomena, it is unlikely that, themselves, they will solve a physics problem correctly. After analyzing responses to the first two questions, the situation would be unfavorable to a modern education. Learning physics relying excessively on traditional teaching and the 51/49 obtained ratio for physics teaching the traditional way (in our study), confirms this fact once more.

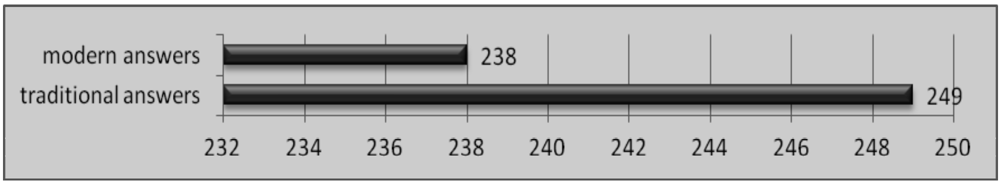

Fig. 4 – The share of learning methods in teaching physics.

How do we interpret these results? The visited schools have physics laboratories, which have acceptably been equipped with computers and Internet connection, and schools libraries have acceptably been equipped with books and publications, including physics bibliography. In a simplified manner, that would mean either that teachers do not know / do not want to apply modern methods, or that the students' disinterest in studying physics leads to a state of indifference from both categories of participants in the teaching and learning of physics (teachers – students). This state favors the particular approach of teaching physics lessons traditionally. Finally, the poor equipment of schools with different other necessary things, the lack of the funds for the acquisition of modern educational software and a lack of personal qualities as far as the teacher is concerned, leads the teacher to use the methods requiring the fewer material resources (sometimes only the text / course book), which naturally is not conducive to quality.

2.4. IF THE APPROACH WAS A MODERN ONE, WHICH METHODS DID YOU NOTICE MOST OFTEN?

An accounting of students' responses led to the situation in Fig. 5.

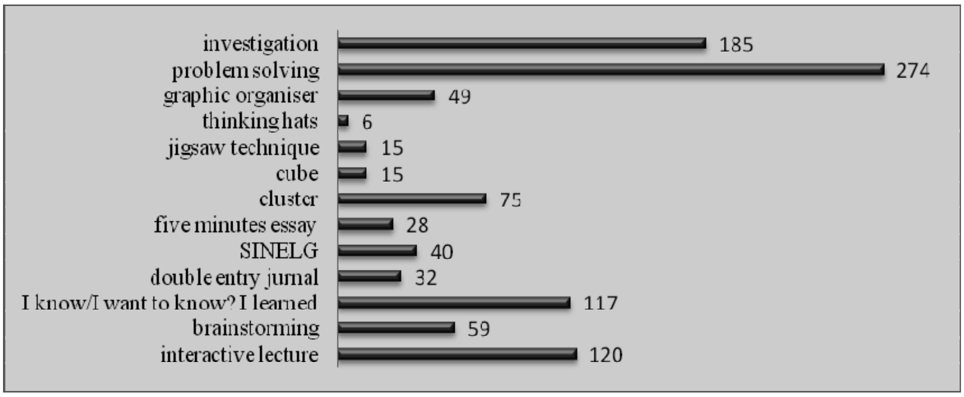

Fig. 5 – The share of interactive methods used in teaching physics.

It is possible that some of these methods have been applied in the classroom but students did not know that they are called that way. It is unlikely that brainstorming or the graphic organizer may not have been widely used in teaching physics. The concept map (graphic organizer) is a diagram showing the relationships among concepts. The concept maps are graphical tools for organizing and representing knowledge [15]. It is possible that teachers may not have been informed during training programs of some modern teaching methods. It is also possible that refresher courses for physics teachers have not pursued the pedagogical and methodical side, which led to the lack of application updated methodology. But there are some methods, even if they were applied on a very small scale, that should have been easily memorized by the students and that should have been mentioned at every opportunity, including in the questionnaire. For example, “The thinking hats" method won only 6 (!) nominations (may be inadvertently mentioned), as shown in Fig. 5. Edward de Bono, internationally acknowledged as a leader in conceptual thinking and thinking as the ability to direct teaching, has created a useful model of thinking called "Six Thinking Hats”. In this method, we identify six styles/roles of communication between learners, each style/role is associated with a colored hat (red, yellow, white, blue, green, black) worn by the students in one of the six appropriate groups of hats. The White hat it is for the data, details, figures, information and the asking of useful questions. The red hat is the emotional hat that encourages the students to allow her emotions, intuition to hold court without any need for justice or substantiation. The black hat presents the negative aspects of the phenomena, plays devil’s advocate and ask questions which are likely to expose weakness in a proposal. The yellow hats see the situations in an optimistic way. The green hat presents the theoretical possibilities, exploration of the unknown or less known areas of the phenomena. It is that invites lateral solutions, creativity and innovative solutions. The blue hat is a meta-cognitive hat. It performs the analysis of possibilities offered by mathematical and physical interpretations of mathematical expressions [16].

The K-W-L (K-what I know, W- what I want to learn, L – what I learned) technique, created by Donna Ogle (1986) activates knowledge on the one hand, and improves the reading comprehension level, on the other hand [17, 18]. It provides a structure (which has three columns) for recalling what learners know about a topic, noting what they want to know, and finally listing what has been learned and is yet to be learned. At the beginning of a lesson or concept unit, the students have to fill out the "What I Know" and "What I Want to Know" columns. Finally, the students have to revisit the second and third columns and adds "What they Learned".

The JIGSAW technique (invented by social psychologist Elliot Aronson in 1971) has been used in the educational process in many countries on all continents, both in the study of specific curriculum subjects and in various social activities. This method can improve the performance of pupils and students in all subjects by using the collaborative learning method. The students are divided into heterogeneous groups of 4-6 students. Each student receives an individual worksheet; numbered 1 to 4-6, which shows the workload (the group is called

Working Group). Then, the students that have the same number on the form will be organized into groups of “experts” who will actually perform tasks on the worksheets. After a period of time agreed with the teacher, the students will assemble in original work groups, where they will “tell” or show their expert work, in turn, to the colleagues, until the “whole” designed by professor, will be achieved through the contribution of each student group, within the group. Basically, each student works (specializes) in a sequence, while receiving the rest from his colleagues [19].

The “Cube” didactic method suppose the utilization of the homonym geometrical shape which has written on its surfaces the following terms: “Describe!”, “Compare!”, “Associate!”, “Analyze!”, “Apply!”, “Argue the pros and cons!”. Learners are divided in six heterogeneous groups, each of them resolving one of these requirements [20, 21].

The Double-Entry Journal is a writing-to-learn strategy that allows students to record their responses to text as they read. The double entry journal is a type of two column, double entry note taking. The students write down phrases or sentences from their assigned reading and then write their own reaction to that passage.

Journal writing encourages reflection and reflection is associated with deep approaches to learning, or with deep learning [21, 22].

Interactive system of marking for improving reading and thinking (SINELG) is a way of encoding the text that allows the learner to active read and understand a pragmatic content. During reading, the students mark in the text: confirmed knowledge (ν), denied knowledge (-), new knowledge (+), uncertain knowledge (?) [21].

The Cluster is a nonlinear brainstorming method. The student writes a word in the middle of the sheet (or blackboard), then write the ideas and phrases that relate to it. Finally, the student makes the logical connection between them [21]. To solve a problem, the student can begins by collecting all possible reasons and solutions by brainstorming and then analyzes them, makes a cluster and evaluates the solutions based on his knowledge [23].

No wonder that problem solving, investigation and interactive lecture occupy the top positions among the interactive methods of teaching-learning of physics. Problem solving is a method often used in teaching-learning the traditional physics, but if students have seen it in the modern sense, it is a success for the teacher. Some of the answers to the questions below prove the contrary. It is well known that solving problems is often limited to a number of / some student / students at the board (of the best at physics) who often solve following the dictation of the problems’ requirements. But there are students who would engage more in learning physics if the range of used methods were more varied, which would primarily produce a greater attraction for the physics classes, even for those who do not attend university studies where physics plays an important role. This should foster understanding of phenomena for a much larger number of students, with much better results in the study of physics. The large number of students who indicated that the investigation method is used mainly in modern physics teaching demonstrates that the laboratory is effectively used in their schools. The problem arises where there are no laboratories or where the equipment in some of them is poor or completely missing. Would the investigative method be the main approach in the study of physics for most schools in rural areas?

2.5. HAS IT BEEN WORKED DIFFERENTIALLY IN THE CLASSROOM? (DIFFERENT TASKS – YES, OR COMMON TO ALL – NOT)

The results of a study run in Bucharest, (150 students took part in this study), during the school year 2008–2009, proved that the differentiate instruction can ensure the increase of the school performance and implicitly of the motivation for studying Physics [11]. In our case, the share of differentiated work used in teaching physics is illustrated in Fig. 6:

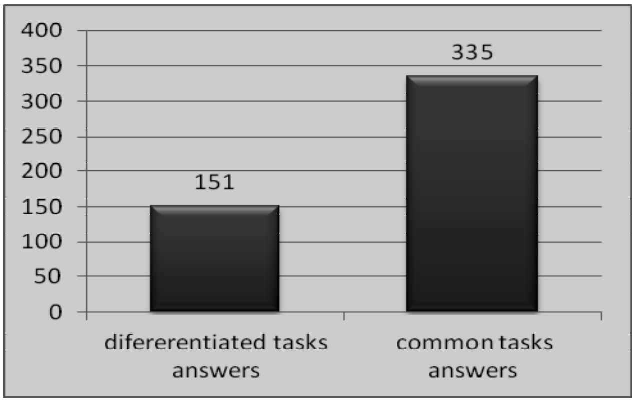

Fig. 6 – The share of differentiated work in teaching physics.

As already stated, the high percentage of negative answers to this question (68,9%), shows that the traditional way is more prevalent in teaching and learning physics. Even solving problems (addressed to the previous question) seems to have been predominantly traditional, otherwise large difference between the percentage (38%) occurring in the share of differentiated work does not support the largest number of responses given for this method of learning physics to question 4.

2.6. HAVE YOU BEEN GIVEN MARKS OR EVALUATED IN PHYSICS (HAVE THE MARKS BEEN GIVEN IMMEDIATELY AFTER THE RESPONSE OR AFTER SEVERAL CLASSES OF PHYSICS?)

Obviously, the situation was expected because marking is the method of "evaluation" most often used in the traditional way of teaching and assessing physics. Is the student, who has not written homework and immediately marked,

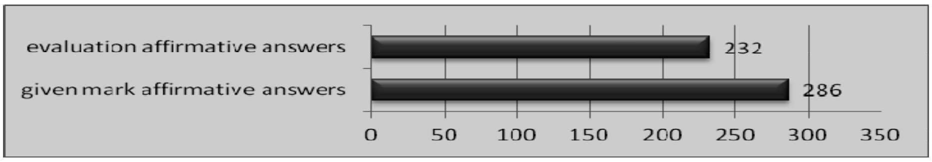

Fig. 7 – The share of given marks and evaluation in physics.

with a low mark of course, total ignorant of the physical phenomena, or can't he solve a problem? Or if he, at some point, does not know a formula or a paragraph from the lesson, won't he be able to recover after the assessment moment? No, motivation and poor involvement are understandable for a student learning physics in this situation as well as his reorienting towards other subjects of study.

2.7. EVALUATION

Evaluation has mainly been done through (see Fig. 8):

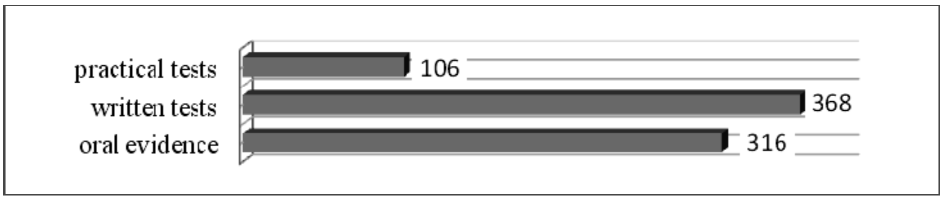

Fig. 8 – The terms of evaluation indicated by students.

Most of the students recorded more than one assessment method, especially combining written and oral methods. Considering the statistics we can but conclude that the physical laboratory is very little used, at least in the evaluation process, although the advantages offered by the educational software especially, include unconventional tests allowing for an optimal feedback [24].

The largest share of the assessment as shown is done in writing. Given the results of the previous questions, the conclusion is that the students were assessed through written work, mostly traditional, which supports the conclusions of the question no. 6.

2.8. DID YOU FEEL MORE MOTIVATED AFTER THE MARK YOU GOT?

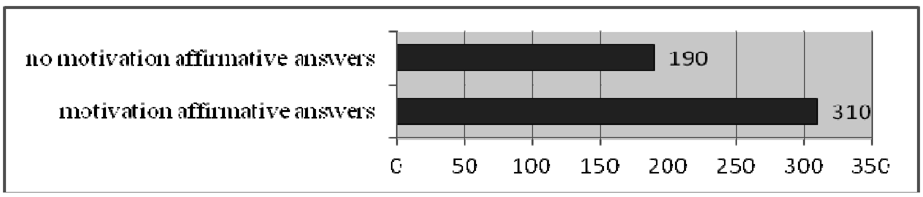

Fig. 9 – The share of the mark's motivation.

The ratio (310/190) = 1.63 of the answers indicating a motivation after the mark as compared with the lack of motivation, suggests that somehow teachers aim to motivate students through marks. If evaluation were predominant, the ratio should be much higher and in close connection with the self-assessment.

2.9. HAVE YOU BEEN HAVE ASKED TO SELF-ASSESS?

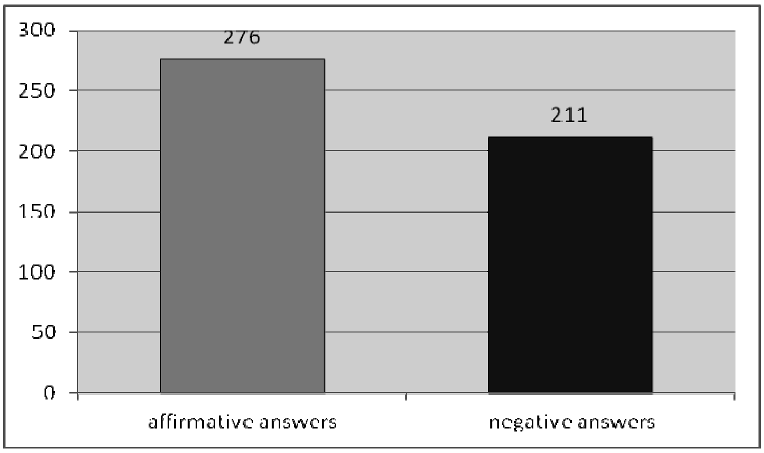

Fig. 10 – The share of self-assessment.

The great challenge for a Physics teacher is to motivate the students to study physics themselves and to self-assess [25]. The ratio between positive and negative responses (276/211) = 1.30 is very close to the relationship between motivation and lack of motivation. This confirms that physics teachers are open to new, but with a minimum consumption of energy and effort. The students like to use methods of interpreting the learning outcomes and self-motivation, characteristic of a process of evaluation, especially when the results of the two activities are close, as in this case. The small value in these reports shows that these methods are only used on a small scale.

2.10. DO FINAL GRADES/MARKS OBJECTIVELY REFLECT ON YOUR KNOWLEDGE?

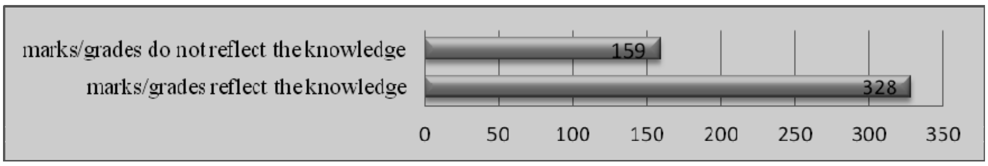

Fig. 11 – The link between knowledge and marks/grades.

The ratio (328/159) = 2.06 represents a lower objectivity of the assessment, thus confirming once again that learning physics occurs predominantly in a traditional manner and in most cases the assessment is limited to marking/grading.

2.11. ARE YOU MOTIVATED IN LEARNING PHYSICS? (DO SCHOOL AND SOCIETY GIVE YOU ENOUGH REASONS?)

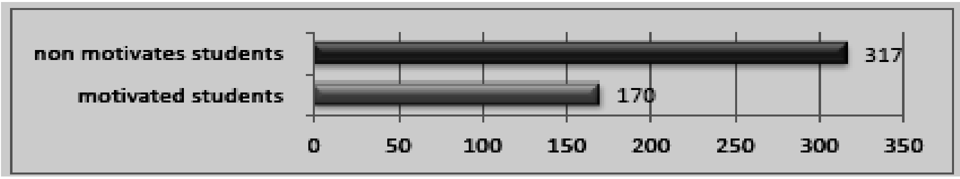

Fig. 12 – Motivation in learning physics.

The obtained values, by processing students' responses, indicate that the maximum one out of three students is motivated to learn physics in view of the opportunities offered by the current Romanian society, considering a future when physics is to play a role. Given that the survey involved only science majoring students, about half of high school students, the others studying the humanities, this means that 15% of all high school students, in the best case, are motivated to learn physics (a student out of six).

2.12. ARE YOU SELF – MOTIVATED TO LEARN PHYSICS? (DO YOU LIKE PHYSICS OR DO YOU PLAN TO HAVE A FUTURE JOB WHERE PHYSICS WOULD PLAY AN IMPORTANT ROLE?)

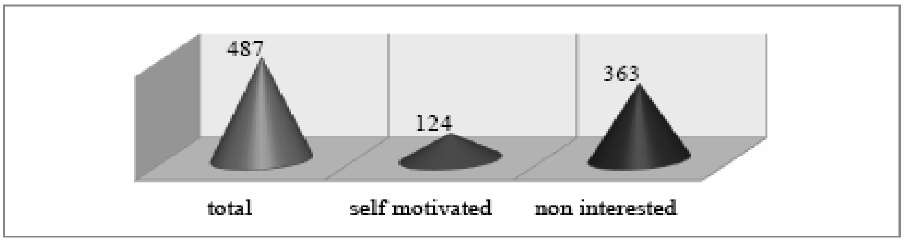

Fig. 13 – The degree of self-motivation to study physics.

The ratio indicating the relationship between self motivation and indifference towards learning physics (124/363 = 0.34) clearly proves that physics is not a favorite subject of study even for science majoring students. According to the value of this ratio, one out of three science majoring students studying would learn physics out of pleasure. What can we conclude? Effective methods of teaching physics should immediately be found and implemented so that students enjoy this subject of study.

2.13. WILL YOU ATTEND A UNIVERSITY OR A SPECIALIZATION IN THE TECHNICAL FIELD? (ONE WHERE PHYSICS PLAYS AN IMPORTANT ROLE)

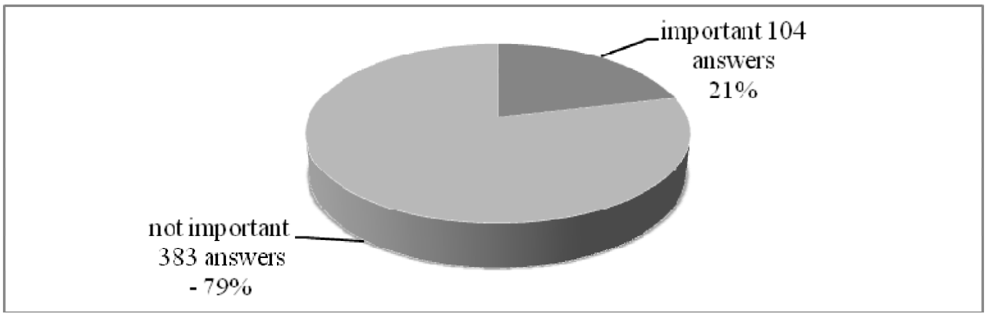

Fig. 14 – The importance of physics to career.

21% of positive responses indicates that only one out of five students (of the science majoring ones) plans to work in an area requiring knowledge of physics. The conclusion is that only one out of 10 high school students would attend university or a specialization in the technical field. The figure is not encouraging because the economy of a civilized country is the engine of development in all sectors, and the poor development condemns the people of that country to poverty. Does Romania tend to become such a state?

2.14. DO YOU WANT TO LOOK FOR A JOB ABROAD? (TO EMIGRATE?)

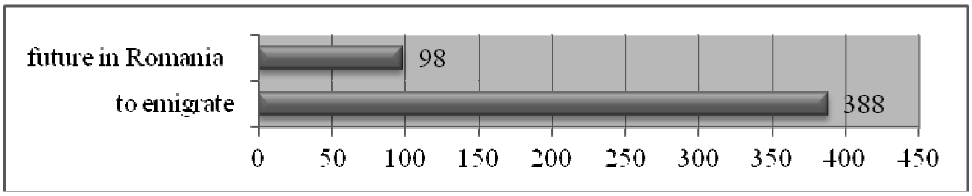

Fig. 15 – Students' future options.

Only one student out of five wants (yet) to work in Romania (98/486=0.21). The other four abroad, and most of them not in the technical field. The conclusion is clear; most students will not learn physics for a future job. Nor will they learn physics for pleasure or interest. The only way currently available to stimulate learning physics is the combination of business and leisure, where pleasure began to prevail, but pleasure can stimulate the interest. The interactive methods of teaching and evaluation represent a way, perhaps the most important, to achieve this objective. Without them, the future is uncertain in the physics curriculum.

3. CONCLUSIONS

It is known that at present, the focus is more on theory and less on practical applications. The textbooks contents are non-adapted to the teaching needs. The curriculum is overloaded without ensuring consistency between the objects of study inside exact sciences area [26].

The most students will not learn physics with pleasure or interest. They also will not learn physics for a future job. The only currently available way to stimulate learning physics is the combination of useful and pleasure, in which the pleasure prevails at the beginning, and then, the pleasure leads the useful. The interactive teaching and assessment methods are, probably, the most importantly, to achieve this objective. Without them, the physics' future is uncertain in school curriculum.

Certainly, we cannot speak about an universal recipe, in increasing attractiveness towards Physics. The new technologies and ever-changing requirements of human society causes a continuously change in teaching strategies. The results will determine which of them will survive.

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