# MACEDONIAN PHYSICS TEACHER

## Society of Physicists of Republic of Macedonia



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# PROJECT-BASED LEARNING: DILEMMAS AND QUESTIONS!

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**Abstract.** In this new era of fast communication and fast change of the technology, fast changes in the process of education are inevitable. Obtaining universal knowledge and skills in the schools is more than necessary. Experiential, hands-on and student-directed learning which are recommended by the educators more than 100 years ago, every day become more and more our need and reality.

One of the approaches, which offer these features, is the Project Based Learning (PBL). There are many discussions on what PBL really is, what are the steps that must be followed, when the approach is PBL and when it is not PBL, how to use it, how to adjust PBL approach to our needs defined by the curriculum and the syllabus etc. Probably the biggest question is how to assess the individual knowledge and skills of each student obtained in the team during PBL.

Here, we will try to clarify some of the most important dilemmas and questions about the essence of PBL, differences and similarities with other approaches. We will also discuss few examples of PBL use in physics teaching and learning for the students of low secondary school (grades 8 and 9).

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## 1. THE HISTORY OF PROJECT BASED LEARNING

Project Based Learning (PBL) has a long history.

Socrates in 5th century BC says, “Learning is not a process of serving information … it is neither the only nor the most important task of the teacher. The teacher’s task is to lead the student, so the student can conclude. I cannot teach anyone anything. I can just make him think.”

In the 19th century, Maxwell asked the colleagues to apply more research and research based learning and less wittily formulated mathematical problems. Cavendish laboratory for physics, established in 1874 by Maxwell was a result of the movement for reform in the education.

The famous German mathematician, Leopold Kronecker, was the first constructivist. Later, Piaget [1], Vygotsky [2] and other researchers set the scientific foundation.

Why do we mention constructivism when talking about the Project Based Learning? Because in the core of the PBL is the process that involves the students in discovering and constructing their knowledge. It is a process based on research, design and everything that means intellectual and physical engagement of the student. It is process which engages minds-on and hands-on.

## 2. CHARACTERISTICS OF PBL

There is no one accepted definition of PBL. Many authors try to define PBL.

Markham et al. explains that Project Based Learning (PBL) is the use of in-depth and rigorous classroom projects to facilitate learning and assess student competence and defines it as a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks [3].

Jones et al. [4] and Thomas et al. [5] explain that PBL is a model that organizes learning around projects, and projects are complex tasks based on challenging questions or problems, that involves students in design, problem solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended period of time; and culminate in realistic products or presentations.

More important than the definition itself, are the attributes of effective projects.

**Project-based learning:**

- Recognizes students' inherent drive to learn, their capability to do important work and their need to be taken seriously by putting them at the center of the learning process.
- Engages students in the central concepts and principles of a discipline. The project work is central rather than peripheral to the curriculum.
- Highlights provocative issues or questions that lead students to in-depth exploration of authentic and important topics.
- Requires the use of essential tools and skills, including technology, for learning, self-management, and project management.
- Specifies products that solve problems, explain dilemmas, or present information generated through investigation, research, or reasoning.
- Includes multiple products that permit frequent feedback and consistent opportunities for students to learn from experience.
- Uses performance-based assessment that communicates high expectations, present rigorous challenges, and requires a range of skills and knowledge.
- Encourages collaboration in some form, either through small groups, student-led presentations, or whole-class evaluations of project results.
- Include wider community in the activities.

The activity, which by teachers is called project, is often used as a fun or change-of-pace events completed after students have been pushed through homework assignments, lectures, and tests.

In PBL, students are pulled through the curriculum by a Driving Question or authentic problem that creates a need to know the material.

PBL is sometimes equated with inquiry-based learning or experiental learning. If you try to google PBL, very often you get to the Problem-Based Learning, which abbreviation is also PBL. Though PBL shares some overlapping characteristics with these terms, there are differences between them.

## 3. ASSESSING KNOWLEDGE GAINED IN PBL

When talking about the PBL, assessment is one of the biggest problems that teachers face. There is often confusion about what and how to assess the individual student, when students work in a team and when everybody has different tasks and activities within the team. But, teacher most often forget that the project activities arise directly from the topics and standards in the curriculum and syllabus. The whole project is shaped in a way to meet the outcomes and standards of the curriculum. The students' activities converge towards one and the same goal – the final product of the project. In order to realize their activities, students have to acquire knowledge first. This knowledge is in accordance with the objectives in the curriculum. If so, then the teacher can assess the students' knowledge and achievement with the tools and techniques that she usually uses.

## 3. DIFFERENCES AND SIMILARITIES WITH OTHER TEACHING APPROACHES

In order to see the differences and to get to the essential characteristics of project-based learning, we will start from the beginning i.e. from Research-Based Learning (RBL). In the foundation of RBL lies the scientific method. There are many different definitions and explanations about scientific method, but we will see here the steps that can be found in almost every version. In the process of the research, researchers:

- Observe
- Pose a question.
- After additional observation and analysis, construct a hypothesis.
- Design research/experiments.
- Analyze the results and make a conclusion.
- Publish the results.

After this, researchers rethink and start the process all over again. When students use this approach for learning, of course, they do not start all over again, but they can rethink, put the results in slightly different situation and circumstances, which will take them to the next topic in the syllabus. In this way, they discover new knowledge by their own. They construct their own knowledge. The activities are directly related to the topics and standards in the curriculum and the syllabus.

Next step in getting closer to the project based learning is the Problem-Based Learning (PbBL). During this process, students:

- Recognize a problem from a situation in the classroom.
- Need new knowledge in order to solve the problem.
- Design research in order to come to this new knowledge.
- Find a solution for the problem based on the acquired knowledge.

The underlined activities are new in this approach, compared to RBL. Since the problem emerges from a situation in the classroom, the problem is authentic. On the contrary, in RBL the problem does not have to be authentic. In RBL the goal is to come to a new knowledge, which is defined by the curriculum and the syllabus. Unlike in RBL, in PbBL the goal is to find a solution for a problem, which emerges from an everyday life, from a real world situation. The acquired knowledge is not a final goal in itself as in RBL. It is only a tool to find a solution for the problem. Knowledge is something that is acquired on the way to the solution. But, it is not acquired because students have to spend their extra time, or for fun. They fill the need for this knowledge. In both approaches students work in teams and they collaborate/cooperate.

Finally, we came to the project based learning. During PBL students:

- Face with a problem outside the classroom.
- Need new knowledge in order to solve the problem.
- Design research in order to come to this new knowledge.
- Find a solution for the problem based on the acquired knowledge.
- Design a final product, which emerges from the solution of the problem.

The underlined activities are characteristics of PBL. They are not present in the PbBL activities. At first sight, it seems like there is not big difference between PbBL and PBL. But, let us take a closer look at the first and the last activities, which are new. Like in PbBL, the problem is authentic and comes from the real world. But, unlike in PbBL, the new flavor here is that this problem is not single. This problem is multilayered. It is complex and consists of more, smaller problems. What is also interesting at this moment is that the problem is interdisciplinary, something that enables us to relate the problem to more than one subject i.e. to integrate more subjects or more topics from one subject.

The last activity, designing a final product in PBL is known from the beginning of the project. Actually, the idea of the project starts from the final product. Unlike in PbBL, the product in PBL is something that has wider significance. It can be applied in the wider community. The final product can be in the form of a program, procedure, document, campaign, theater play, technical product etc.

## 4. WHAT STUDENTS GET FROM PBL

PBL covers all modern trends in education.

Students are at the center of the learning process.

Students work in teams and they collaborate. Collaboration in the process of learning is a level higher than the cooperation. Note that the student takes the responsibility for its acquired knowledge, but also he/she takes responsibility for the knowledge of the whole team. PBL creates collaborative relationships among diverse groups of students [6, 7].

Students cooperate with the community. Learning community is not only the classroom anymore. The Learning Community becomes multidimensional, public and unpredictable [8].
No matter of the subject and the topic, students learn how to do a research, how to organize the teams, how to communicate.

Very important moment is that they learn to articulate their thoughts, they learn how to explain, how to convince.

PBL creates positive communication. Students learn to advocate, to defend their ideas, but at the same time to listen the opponent and to be open for others opinion.

PBL overcomes the gap between knowledge and thinking. Students “know” and “do”.

PBL develops the habit for lifelong learning.

PBL meets the needs of learners with varying skill levels and learning styles.

Students with different abilities and different interests work together: organization, experimenting, crafts, drawing, writing, designing…

Very often, the engineers do not have communication and teamwork skills. Current programs do not provide sufficient design experience to students, too. There is a lack of awareness amongst students of the social, environmental, economic and legal issues that are part of the reality of the modern engineering practice [9]. All these moments can be recognized in the skills that students can obtain by practicing PBL.

Very important moment is that PBL enables application of the technology [10, 11].

## 5. WHAT TEACHERS GET FROM PBL

Perhaps the first question that usually arises is: do I have time to do this project? PBL should not be taken as taking time away from the regular curriculum. Project should be considered as a central method of teaching and learning that replaces conventional instruction method. This project teaches students the same essential information you might teach them through lecture and discussion. Of course, it is not possible to go through the whole project just during the classes. One of the reasons is that the project involves cooperation with the community. In some situations, it is possible to bring people from institutions outside of the school. For example, at the beginning of the project or during the realization of the project, when there is need to make short discussion, short overview of what has been done or short consultation. But, the real interaction with the community is at the institutions. The second reason is that the activities are too many and too complex to do it only during the classes. Part of the activities can be done as homework, sometime even extended homework.

This shows that there are some activities that have to be done by the students. Traditional instruction engages teachers whole time of the class with talking, explaining, doing experiments, watching students…This is not easy, in particular for the novel teachers. PBL shifts all activities towards students. The students take part in designing the whole project: communication with the community, designing research, doing research, collaborating between themselves, they have responsibility for the success of the whole project. And all that with the help of the teacher. This means that the teacher is not passive. The teacher leads the students, give them direction if they got lost, helps them with the organization. The teacher is their older partner who is always there to help them if they get stuck.

The teachers' experience shows that once the teachers fell comfortable with PBL, they usually find teaching with projects to be more fulfilling and enjoyable.

Most of teachers claim that active learning is vital. But, not all of them react in the same way to such way of learning. Some teachers say that projects are chaotic or messy. This a good reason for a teacher to ask herself/himself on the teaching style and skills. How will he/she operate in PBL environment?

The teacher has to test herself/himself, whether he/she is a leader or a manager. Leaders facilitate problem solving in a group and help the group find their own solutions. Managers, on the other hand, prescribe outcomes and control the process on the way to finding those outcomes. The best way is to go back and forth between the two roles. But, if the teacher is not sure what will happen when the control is left to the students during the project activities, he/she does not have to avoid projects. Teachers already know many of the elements of PBL, and have used them, but may not be aware of it. It is good to start with those small elements and build them up step-by-step. This results in small projects at the beginning, which will grow and finally come to a big project.

PBL does not offer possibility to cover all or many topics. Sometimes it is the topic, which is not possible to go through PBL. Sometimes, it is the time that limits us. But in the case of good education, less is more. If the teacher is pressed for time and need to include many topics in the instruction during a year, it is good to think about the concept of "uncoverage" i.e. cover-discover approach. This means making a deliberate decision about topics that you want to teach in depth versus topics that can be simply "covered". Which of the topics can be easily and successfully handled through lectures or textbook assignments? Which of the topics require more depth? Identify the topics with the most important ideas and concepts in your curriculum and incorporate those topics into projects. Those are the topics with which you want the students to tackle. The remaining topics you can deal with through direct instruction. In other words, the teacher can use direct instruction and less time for the concepts that are easier to handle and maybe on the lower level of the importance scale (if it is possible to grade) in order to cover the topics and goals in the syllabus. But, the concepts that are more important have to be discovered by the students.

Teachers in low-performing school often pose a question: can PBL work in my school? Yes, it can, because, as it was mentioned earlier, many of the PBL elements teachers already know and apply. Of course, it is not possible to quit direct instruction. Discussion with the students and between the students, inquiry, experiments, cooperation with the community, designing things is all elements of PBL. The relative quantity of each element in the PBL depends on the topic, circumstances in the school and community, teacher's and students' skills. Sometimes, if the students are less skilled, it will be necessary to include more direct instruction. But, teachers must not quit projects!

When the teacher develops a project, she has to start thinking backward from a topic. Project ideas come from articles, issues, current events, conversations and wonderment. Often, they emerge from discussions between members of a teacher tea. Once an idea comes to the teacher, she has to work backwards to shape the idea in order to meet outcomes and standards of the curriculum.

## 6. EXAMPLES

Let's take a look at one example in order to see and understand the difference between the three approaches explained before.

**Example Research Based Learning**

Objective: Discover the dependence of the electric resistance on the characteristics of the conductor.

The research and experiments are designed by teacher and students, jointly.

Students are organized in teams. Each team has different task. Each team has to come to some conclusion about the dependence of the electric resistance. After the experiments are done, the students exchange the results between themselves; discuss the results and come to the final conclusion. The law for electric resistance is discovered.

**Example Problem Based Learning**

The students study different electric circuits. The students have to construct a circuit with few resistances. There is not a resistance with certain value in the physics classroom. The students have to make such resistance. In order to make it, first they have to discover the dependence of the resistance on the characteristics of the conductor. It means in this part of the PbBL comes the module of RBL. After the research is done and the law of electric resistance is discovered, the students can make the required resistance.

**Example Project Based Learning**

For some reason the school has to construct and design electric heater. In order to fulfill this task the school addresses to a factory which produce electric devices. During this process, students should take the next activities:

1. Take into account the power of each heater.
2. Discover the law of resistance.
3. Adjust the power and the resistance of the heater.
4. When constructing the heater think about its design, which has to answer the application.

5. Construct and incorporate the safety device in the heater.

6. Construct and incorporate temperature controller (thermostat).

7. Write and design a manual for the heater, which will contain the procedure for using and safety precautions.

7. Write and publish a report?

From the last example, one can see that the integration in PBL is inevitable. Besides the physics, which lay in the core of this project, subject related to technology can also be involved, since one of the goals of the project is to construct and design the heater. Design of the heater can also be included in the classes of arts. All written material can be included in the classes of mother tongue or even in foreign language. Report can also be given in electronic form (power point presentation, website, blog etc) which means that the classes of computer science (informatics) can also take part in this project.

**Example Introductory Project**

One of the projects, which will introduce the teacher and the students in PBL and will help with the later projects, is mapping the community. Design a project to discover all institutions in the community. The final product will be a categorized list of factories, faculties, museums, institutes, ballet studios, churches, theaters, cinemas, galleries, building enterprises etc. Later this list can be used as a source for ideas and some of those institutions and companies could be involved in the future projects.

Here are some examples of projects and possible questions to answer and activities to do within those projects.

**Example: Campaign for recycling "Why recycle at all?"**

Why should we recycle? What can be recycled? Visit a factory that produces paper, glass, aluminum, rubber, plastic or anything that can be recycled. From the experts obtain information on the energy and water consumption for production, on the emission of harmful substances etc.

Visit an NGO, which would be interested in participating and supporting such project. Visit the ministry of environment or similar.

Visit an institution which works in the area of recycling and obtain interesting information. Are they satisfied with the way of collecting material, is there any problem, is there anything that can be improved etc. Is there a possibility to expand the recycling with other materials and under what conditions?

What the people know about recycling? Organize an inquiry. Design a questionnaire.

Make a material for the campaign: leaflet, play, show, website etc.

Which materials decompose in the nature? Make a research: bury fruit, vegetable, piece of meat, paper (with a various quality), plastic (with a various quality), can etc.

**Example: Industry "How to improve the quality of a product? What is the competition?"**

Make e list of the factories in the town, in wider area or in the state?

Find out is it possible to buy their products in the stores?

Find the products and manufacturers of similar products that can be found in the stores?

Discuss with the sellers/merchants: why do they supply these products and not some others?

Test the products. Prior to testing establish criteria, what and how to evaluate.

What would the students change: quality, shape, packaging, commercials or something else?

## 7. CONCLUSION

PBL is not the ideal approach. PBL cannot be applied in every situation. For example, PBL is not appropriate as a method for teaching certain basic skills such as reading or computing; however, it does provide an environment for the application of those skills.

Research component in the project must not be forgotten. Investigating authentic problems [12], designing experiments with devices that are used in everyday life [13] and analyzing results, gives more quality knowledge, understanding of the basic concepts and fights common misconceptions [14].

However, PBL is still in development stage. Some authors say that there is not sufficient research or empirical data to state that PBL is a proven alternative to other forms of instruction. However, PBL is so complex that it gives opportunity to use all possible forms of instruction. Blended learning finds its natural environment in PBL. But, nothing is ideal.

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# УЧЕЊЕ БАЗИРАНО НА ПРОЕКТИ: ДИЛЕМИ И ПРАШАЊА!

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**Апстракт:** Во време на брзи комунукации и брз развиток на технологијата, неизбежни се брзи промени и во образованието. Добивање унивезрални знаења и вештини е повеќе од потребно. Учењето базирано на искуство и настава насочена кон ученикот, кои се препорачуваат последниве 100 години секој ден стануваат се повеќе потреба и наша реалност.

Учењето базирано на проекти (УБП). Постојат многу дискусии за тоа што точно значи УБП, кои се чекорите кои мораат да се следат, како да се усогласи со наставната програма, како да се имплементира во наставата и таканатаму. Можеби најголемиот проблем кој ги доведува наставниците во недоумица е како да се оцени знаењето стекнато низ овој начин на учење.

Многу наставници не можат да направат разлика помеѓу учење базирано на истражување, на проблем (УБПб) и на поект. Учење базирано на истражување е основна клетка на другите два приода. Тоа е составен дел на учењето базирано на проблем и проект. Малку потешко се прави разлика помеѓу УБПб и УБП. Кај УБПб ученикот е доведен во проблемска ситуација.За да ја реши, потребно е да помине низ процесот на учење (пожелно е тоа да биде учење низ истражување). Стекнатото знаење ученикот го користи за решавање на проблемот. Решението има локален карактер, односно го решава проблемот во училницата/училиштето.

Кај УБП, проблемот не е од локален карактер, туку тој доаѓа од надвор, од пошироката заедница. Проблемот е комплексен, односно повеќеслоен, се состои од повеќе помали проблеми. Во процесот на решавање на проблемот е вклучена и пошироката заедница. Дел од процесот на учење може да се одвива и надвор од училницата, од практични ситуации и заедно со експерти од други институции, различни од училиштето. УБП може да вклучува и интегрирана настава. Решението е готов производ во вид на изграден уред, производ, презентација, документ, претстава, кампања и слично.

Кога зборуваме за оценувањето стекнато низ УБП, мора да се каже дека целите кои УБП си ги поставува се идентични со они дефинирани со наставната програма. Тоа значи дека материјалното знаење кое треба да се стекне е истото тоа кое би се стекнало и низ традиционална настава. Оттука следи дека оценувањето на индивидуалното знаење на секој ученик може да се направи на усталениот начин кој наставникот го применува вообичаено. Дополнително, низ УБП се стекнуваат универзални знаења и вештини, како што се тимска работа, соработка и комуникација во рамките на тимот и надвор од него, организација, одговорност за стекнатото знаење и крајниот производ од проектот.

Се разбира, УБП не може да се применува во секоја прилика и за секоја наставна единица и тема. Тука станува збор за процесот на покривање и откривање.  Работа на наставникот е да оцени кои се поимите кои може да се поминат низ традиционална настава, а кои е потребно да се проучат подлабоко. Поинаку кажано наставникот треба да оцени кои се поимите кои не можат да се совладаат со УБП, кои може лесно да се совладаат со традиционална настава или кои не мора да се проучуваат подлабоко, односно поими кои треба да се покријат, затоа што се дел од наставната програма. Од друга страна, има поими кои може да се совладаат низ УБП, кои не може да се совладаат со традиционална настава или кои поради својата важност треба подлабоко да се проучат, односно поими кои ученикот треба сам да ги открива.

Примерите во трудот ги илустрираат овие моменти.

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# PHYSICS LAB, CRITICAL THINKING AND GENDER DIFFERENCES

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**Abstract**: This paper deals with the relationship between teaching methods and techniques on one hand and critical thinking on the other hand, with special emphasis on laboratory method and practical work in teaching physics. Classroom lecture with memorizing facts and recall information does not develop critical thinking. But, is the laboratory practice appropriate method in terms of fostering critical thinking? Statistical analysis based on pretest and posttest results show that it is not effective method of teaching critical thinking skills. Additionally, some statistical inferences were made for further insights. Using $t$ test we found no significant difference between male and female students.

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## 1. INTRODUCTION

This article examines the effectiveness of one non traditional teaching method to stimulate secondary school students in critical thinking (CT). The main question this paper will seek to answer is: “Is physics lab and practical work effective teaching method for stimulating secondary school students’ CT skills?” The research study is based on the assumptions that lecture method, as a traditional form of teaching is not appropriate for stimulating and development of students’ CT. Along with effectiveness of the teaching method we examined gender differences in achievement on CT test.

### Critical thinking

In recent years, especially in the last two decade of 20$^{th}$ century, educational community has evidenced an increased recognition of the importance of CT. Although concerns about deficiency of higher-level thinking skills among students were raised in the 1970s, educators viewed the 1980s as a CT movement due to the increased attention to thinking skills [1]. CT has been identified as key component of education in recent years.

CT is complex mental activity that requires higher levels of cognitive skills in problem solving, decision making and drawing conclusions. Literature reviews of definitions of CT reveal that definitions of this concept vary. According to this, there is no universally accepted unique definition of CT. Sometimes authors suggest that it is better not to be defined, but explained by its essential components and features, dimensions, and characteristics as how CT experts have done. In this way a well-cultivated critical thinker [2]:

- Raises vital questions and problems, formulating them clearly and precisely;
- Gathers and assesses relevant information, using abstract ideas to interpret it effectively;
- Comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards;
- Thinks open-mindedly within alternative systems of thought, recognizing and assessing, as need be, their assumptions, implications, and practical consequences;
- Communicates effectively with others in figuring out solution to complex problems.

When CT is defined in terms of abilities, it seems there are some abilities that would appear to be independent, such as: ability to apply principles, ability to interpret data and abilities associated with the nature of proof [3].

### Gender difference

People struggle for freedom and equality. Boys and girls spend a lot of time together in school during their formal education. Gender differences in science have been discussed for years. These differences, if any, can be grouped into two main categories: differences in science ability and differences in attitude towards science.

Findings from TIMSS showed that boys had significantly higher mean science achievement than girls at eighth grade internationally and in many countries. It is not a rule because national trends indicate mixed results regard to the gender difference in science achievement. There are major gender differences in some countries and fewer gender differences in others.

For example, TIMSS 1999 showed no statistically significant gender difference (or no any gender difference) in science achievement among Macedonian eighth grade students [4]. Four years later (TIMSS 2003) another generation eighth grade student from the Republic of Macedonia showed statistically significant gender difference in science achievement. Although on average, across most of the countries, boys outperformed girls at the eighth grade, gender difference of Macedonian students favored girls [5].

Graybill found evidence of a gender difference in problem-solving tasks, where girls lagged behind boys in the development of logical thinking ability as defined by Piaget and Inhelder [6]. The differences start to show around the age of 11 years. A moderate correlation has been found between positive attitudes toward science and higher achievement in science [7]. Anyway, it seems the issue of why boys perform better than girls in science or why women do not select science as a career is complex and very controversial.

## 2. METHODOLOGY

A parallel-group design was used in this study. Experiment with control $(N_C = 80)$ and experimental group $(N_E = 83)$ was performed to scrutinize the possibility of stimulating CT skills with this teaching method. Sample students were 10th grade, age between 15.8 and 16.6 years.

In order to have an equal control and experimental group (C and E) classes were selected according to the physics marks, overall achievement and the teacher's suggestions.

Lab physics and practical work was used in E during teaching the unit "Electric current". Many practical activities, such as demonstrations, conducting experiments and research activities were performed in E.

Students were pretested and posttested using CT test. The test was developed by the authors. Evaluation process has included checking, revision and modifying the questions using both pilot and focus group methods. This test measures subject specific CT skills in a specific content area-physics. Students were scored on a scale ranging from 0 to 50, with higher scores representing the better achievement. Test reliability was measured using test-retest method. Stability index was calculate on the other group of fifty-one students and calculated value is $r = 0.76$ ( $p < 0.01$).

## 3. RESULTS

After checking the normality of score results frequency distribution (Kolmogorov test), hypothesis of equality of C and E was tested by parametric *t* test. Pretest results were analyzed statistically and the descriptive statistics (minimum, maximum, mode, median, mean and standard deviation $s$ ) is shown in Table 1. The final pretest sample included 154 students, 50% of them male and 50% female.

**Table 1.** Descriptive statistics, pretest (BT_01)

| Pretest BT_01 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group | $N$ | male | female | min | max | mode | median | mean ( $\overline{X}$ ) | $s$ |
| C | 77 | 41 | 36 | 0 | 37 | 4 | 11 | 13.65 | 9.45 |
| E | 77 | 36 | 41 | 0 | 28 | 9 | 12 | 12.40 | 6.00 |

Firstly, before making inference normality distribution was tested using Kolmogorov test. Statistical significance was set at $p < 0.05$. Results show that students' score are normally distributed. After that, the pretest scores were analyzed using the two-tailed *t*-test for two independent samples to guarantee the equality of the groups prior to instruction. Calculated value $t = 0.980$ is less than $t_{\alpha=0.05}(\text{df} = 152) = 1.98$, therefore we accept the null hypothesis $H_0$ : $\overline{X}_{\text{E}} = \overline{X}_{\text{C}}$. Posttest results are shown in Table 2.

**Table 2.** Descriptive statistics, posttest (PT_01)

| Posttest PT_01 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group | *N* | male | female | min | max | mode | median | mean ($\overline{X}$) | *s* |
| C | 73 | 40 | 33 | 0 | 37 | 24 | 20 | 19.08 | 8.17 |
| E | 71 | 36 | 35 | 0 | 43 | 32 | 22 | 20.99 | 10.99 |

As it was expected students' scores on posttest were much better then on the pretest. Although, posttest results of students in E are slightly better than the ones in C, we can see that, there is almost no mean difference between C and E. The data on the graph below show normal distribution of the relative frequencies.

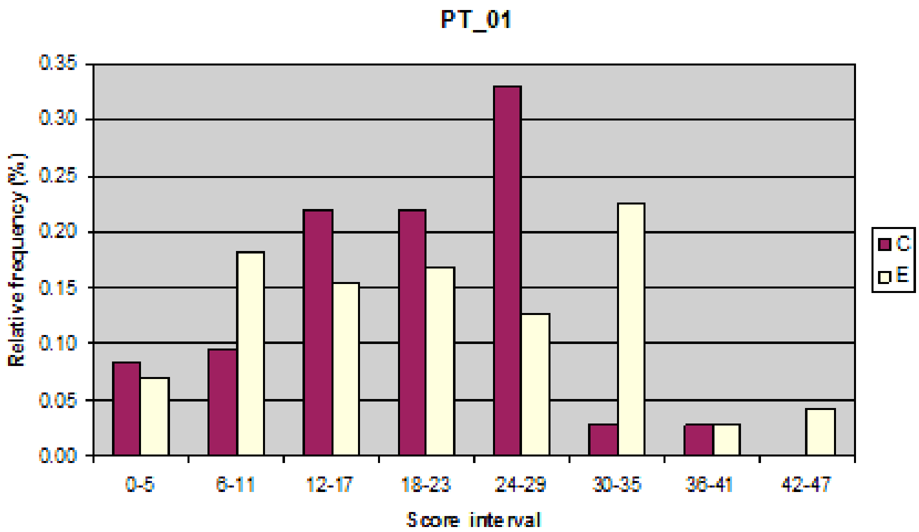


**Fig.1:** Posttest results frequency distribution.

We used one-tailed *t*-test for measuring the significance of the difference between the means of the two independent samples. Calculated value $t = 1.18$ is less than tabulated value at $p < 0.05$, so there is no statistically significant difference between the means of the groups.

In order to characterize the change between pretest and posttest scores, normalized change $c$ was used. Scatter plot of normalized change versus pretest score (%) is shown in Figure 2. Average value is $\overline{c} = 0.18$ and this number indicates a low normalized change.

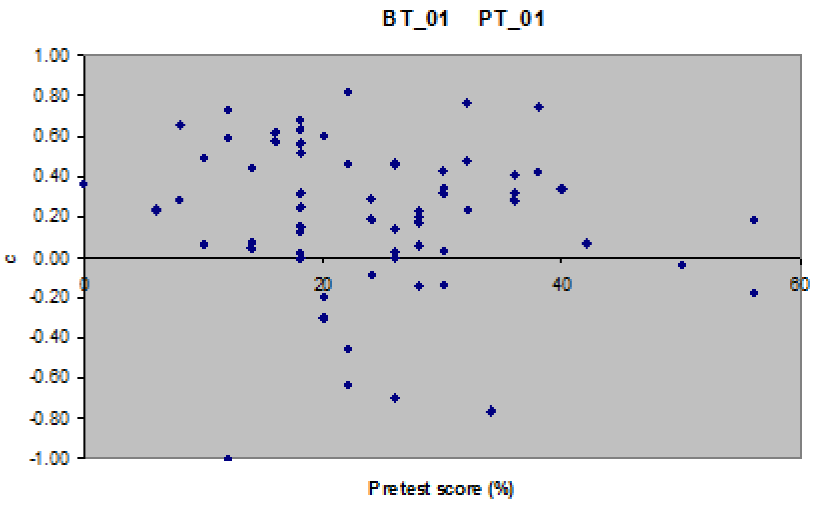


**Fig.2:** Normalized change.

We also used $t$ test to examine gender difference. It was conducted for both, control and experimental group. Descriptive statistics and $t$ test results are shown in Table 3 and Table 4.

**Table 3.** Descriptive statistics and $t$ test results, posttest (PT_01)

| Control group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group | *N* | min | max | mode | median | mean | *s* | *t* | sig. |
| male | 40 | 4 | 32 | 24 | 18 | 17.93 | 8.03 | 1.33 | n.s. |
| female | 33 | 0 | 37 | 24 | 21 | 20.48 | 8.23 | | |

n.s. means no significant

**Table 4.** Descriptive statistics and $t$ test results, posttest (PT_01)

| Experimental group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group | *N* | min | max | mode | median | mean | *s* | *t* | sig. |
| male | 36 | 0 | 43 | 6 | 22.5 | 20.89 | 10.92 | 0.076 | n.s. |
| female | 35 | 4 | 42 | 32 | 20 | 21.09 | 11.22 | | |

From the Table 3 and Table 4 one can see that calculated $t$ values of 1.33 and 0.076 are less than the critical value of 1.96 at $p < 0.05$ (two tailed $t$ test). Based on this, the null hypothesis, which claims that there is no statistically significant gender difference, is accepted.

This means that for both, control and experimental group, there is no significant difference between male and female students in their achievement on CT test. Therefore, there is not significant gender difference, no matter which teaching method is used.

## 3. CONCLUSIONS

The present study compared effectiveness of non traditional versus traditional lecture-based teaching method on students' CT, measured with subject specific CT test. Results show that lab physics and practical work teaching method is not effective in terms of stimulating CT skills, because the data have indicated no statistically significant difference between groups. Also, the findings of the study indicate that the gender difference does not exist in terms of students' achievement on CT test.

Since development of CT skills takes time, further researches are needed to evaluate effectiveness of non traditional teaching methods. Maybe two months of instruction time is too short to have a significant change in students' CT. An additional recommendation for further analysis relates to the research instrument. Sometimes, it is useful and researchers recommend using more than one assessment tool for a comprehensive and valid measurement due to the multidimensional aspects of CT.

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# LIGHT POLLUTION A TOOL FOR PHYSICS AND ASTRONOMY EDUCATION

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**Abstract.** The problem of light pollution is well known in the world, which is not case in our country. Beside the loss of the night sky, the other negative impacts are: damage to the environment, sky glow, human health consequences and disturbing of sensitive ecosystems. The students from High School "Orde Copela" in Prilep continuously for five years in succession including this year (2012) perform activity within the international educational project "Globe at Night event". They estimate the light pollution by measuring the limiting magnitude of stars from the constellation Orion or Leo and additionally using the Sky Quality Meters to map a city light pollution at different locations to identify dark sky oases and even measure changes over time. During these investigations through the subjects in physics, astronomy and computer sciences the students are familiarizing with the problems of light pollution, which make them to appreciate the heritage and healthier environment [6].

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## 1. INTRODUCTION

What is light pollution? The light disappears without a trace as soon as we turn off the lights. Someone would probably think that it is impossible to call that pollution!? Unfortunately, the answer is opposite; light can really pollute the environment. Furthermore, light pollution can have a negative effect on the total plant and animal life, as well as on the humans. Light pollution is an unwanted consequence of outdoor lighting and includes such effects as sky glow, light trespass, and glare.

Men have artificially lit up everything that has come their way. Sky glow phenomenon mostly irritates astronomers. It is a type of light pollution when the public city lights are directed toward the sky where the rays of light in the atmosphere scatter and reflect from the aerosols back toward the ground. Space lovers have lost their stage and the astronomical observations are merely impossible. Light pollution has turned the night into a half-dawn. As a result, today it is practically impossible to see the stars from the city. The "Milky Way" for us exists only in the fairy tales, because we cannot see it [2].

In addition, there are health consequences of exposure to artificial light at night some of them are increased headaches, increase in anxiety, and reduced production of hormone leading to cancer. Many plants and animals suffer from the newly risen circumstances, some of them are on the verge of extinction and some are already extinct. Birds do not build their nests near the sources of artificial light; they become disoriented at night. Flowers do not close completely and therefore they are exposed to weather conditions. The proud owners of the “decorative light balls” are unaware of the fact that they have out casted tens of animals and plants from their gardens, thus bringing to their global extinction. In fact, Mother Nature acts as we, the intolerant and ignorant humans, tell her.

Everywhere we travel, we can see that the streets, the squares, the crossroads are over-illuminated with inappropriate artificial light. Sometimes the glare light redirecting in the eye causes loss of contrast and leads to unsafe driving conditions. Are we aware of the number of driving accidents caused by over-illumination?

The problem of light pollution has not been seriously considered so far. Fortunately, the governments of some countries have brought many laws and regulations related to the light pollution.

**Describing the light pollution**

There are three types of light pollution:

*Glare* - when there is a lot of light in the background. Can you clearly see the faces of the children who stand in front of the house that is too illuminated (Fig. 1)?

Fig:1. Glare light pollution.

*Light trespass* - is when unwanted light enters one’s property. Would you be able to sleep if your bedroom’s window faces the light in the photo above (Fig. 2) [1]?


Fig:2. Light trespass.

*Sky glow* – the most important in astronomy. Would you be able to see the stars in the photo left (Fig. 3) [1]?

As we already saw, these are illustrations of the three types of the light pollution and are made in the town of Prilep.


Fig:3. Sky glow.

**Problem solution**

Many things can be implied in order to reduce the light pollution. For example, the lighting fixtures should be improved, meaning we should use ecological lights of better quality, which should direct their light more accurately towards where it is needed [2].

These types of lights are: ecological, safe, economical, can lower the light pollution and they light the surface that needs to be lit, they are also traffic - safety and public - safety friendly, cost less and use less energy. However, we also have to mention the awareness of each human being rationally to use the light and to safe energy in any possible way.

When non-ecological light sources are used they do not illuminate the required surface, have a negative impact on plants, animals and humans and cost more. When more energy is wasted, more light is wasted, too [2].

## 2. GLOBE AT NIGHT

The GLOBE at Night program (GaN) is an international citizen-science campaign to raise public awareness of the impact of light pollution by inviting citizen-scientists to measure their night sky brightness and submit their observations to a website from a computer or smart phone.

The total number of measurements according to the Globe at night campaign until now is 83 000, made in 115 countries. This Campaign is held for 7 years in succession, and these results make it one of the most successful campaigns against light pollution [4].

The total number of observations during the 2012 GLOBE at Night campaign is 16 850, performed in 92 countries. 20 of those countries contributed with about 95% of all observations. The top 20 countries are United States (6072), India (2472), Poland (1196), Argentina (879), Germany (859), South Korea (828), China (628), Chile (488), Croatia (374), Romania (324), Spain (278), Canada (254), Mexico (217), France (206), Czech Republic (173), Hungary (142), South Africa (130), Uruguay (122), Macedonia (115) and Slovakia (98) [4].

About 1 out of every 2 observations of limiting magnitude gave a value of 3 mag or 4 mag (measurements contributed by medium to larger sized cities), 80% of the measurements (or every 4 out of 5 measurements) were taken in light polluted areas and less than 20% (less than every 1 out of 5 measurements) from areas where we could see the Milky Way Galaxy. The numbers are consistent with what the International Dark-Sky Association finds for the United States.

## 3. RESULTS FROM THE OBSERVATIONS OF GLOBE AT NIGHT IN SOU "ORDE COPELA", PRILEP, MACEDONIA

Our school had participated for five years till now. It was started in 2008 and was the first school from Macedonia, which took part in GaN. Globe at night is very useful for us because we have used materials for the contests, the students find it very interesting activity, because it brings them closer to the science, they become citizents-scientists, ect. Definetely, if we tell about the light pollution to everybody we will be very successful. Also, with this activities increases the level of conscience, IT skills and language skills of our students.

**Instructions how to catch a star in six easy steps:**

Determining longitude and latitude. For this purpose we use the GPS - unit and Globe at night web pages;

1. Locating the constellation Orion or Leo [Fig. 4 and Fig. 5] one hour after sunset (8 to 10 o'clock pm. local time);
2. Magnitude observation using the magnitude graph by Globe at night web site. Here we compare our night sky to the other magnitudes shown in the graph below (Fig. 6 or Fig. 7) in order to decide on the magnitude of our night sky;


**Fig. 4:** Constellation Orion.

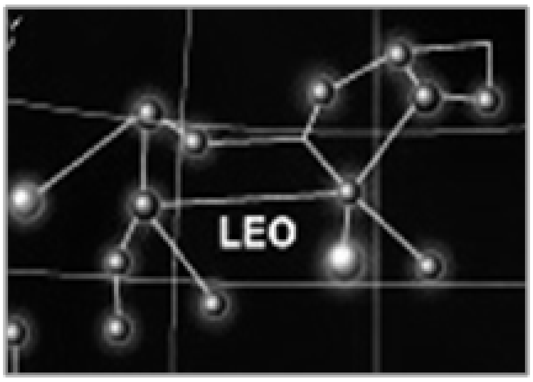


**Fig. 5:** Constellation Leo.

3. *Using the SQM-L* to measure sky brightness;
4. *Sending data.* In order to record the measurements and observations we fill in the forms, which can be found on the Globe at night web page: www.globeatnight.org.
5. Comparing observations with the other thousands of observations around the world [5];

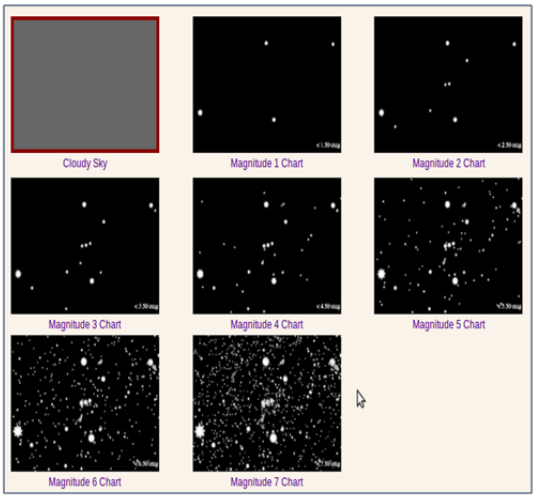


**Fig. 6:** Magnitudes charts (Orion).

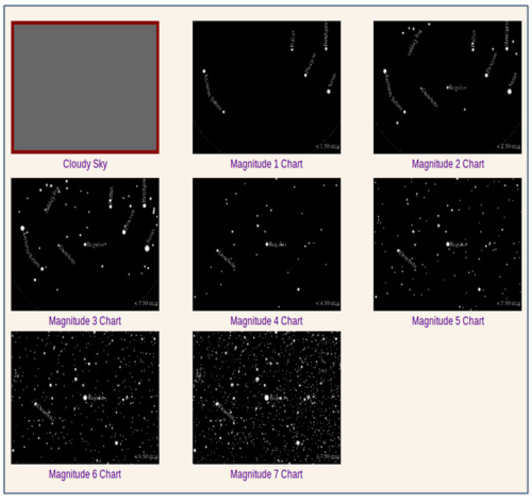


**Fig. 7:** Magnitudes charts (Leo).

### Using Sky Quality Meter (SQM) to Measure Sky Brightness

The measurements conducted using the SQM (Fig. 8) take the activities in GaN program to a higher level - the participants in the Globe at night program gain scientific experience, as well as the measurements are more precise.


**Fig:8:** SQM – L model.

There are two models of SQM's. The SQM-L-model is newer, but both of them are easy to use. The difference between the models is the location of the display and the power button. On the SQM-L model [Fig: 8] the power button and the display are on the same side, which means that you would not have to change the position of the meter in order to observe. On the SQM model the display and the sensor are not on the same side [1].

The observations take place outdoors, in the evening, and after sunset (from 8 p.m. to 10 p.m.). The night sky should be watched before the Moon is set too high, and the sunset occurred at least one hour ago. Otherwise, the glare from the Sun and the Moon will affect the observation.

The SQM is influenced by the outdoors temperature, thus it is better to leave it outdoors at least for 5 minutes to adjust to the temperature and then to continue with the observation. The meter should not be used near any streetlights or any other source of artificial light, nor under the shadows of buildings and trees. Another rule states that the SQM should be away from a street light at least 7.5 meters, if possible. The SQM should be held above the head pointed towards the zenith, so that the shadow or the reflection of the observer would not influence the observation. Also, the instrument should be held firmly, without moving or shaking. The button should be pressed only once in order to start the observation. The SQM will beep every second while collecting the photons. The observation is finished after the last beep, and then the display should be read. Under the urban sky (in urban areas), the result is shown almost immediately. When the sky is very dark, the results appear after a minute or more [5]. To complete the procedure, the serial number of the instrument is required; it will appear if the start button is pressed for one second. Firstly, the temperature appears in degrees Celsius {ºC} and degrees

Fahrenheit {ºF}, secondly the result from the observation, and thirdly the serial number of the instrument.

SQM and SQM-L measure how much light is registered by the sensor. Then the meter transforms the quantity of light into unit magnitude on arc-square second. The higher the number shown on the display, the darker the sky is. The value of 21 presents a very dark sky, but the value of 16 presents a light polluted night sky. SQM is a precise instrument with a precision of ±10 % (± 0,10 mag/arc $sec^2$). The magnitude arc square second is a logarithmic measuring unit, so when there are great changes in the brightness of the sky there are only small value alterations shown by the instrument.

The difference of one magnitude is defined as a factor of $(100)^{(1/5)}$ in received photons. As a result, the brightness of the night sky of 5,0 mag/arc $sec^2$ equals the declination of degree of photon arrival for 100 factor. We can transform the SQM-L value from mag/$arcsec^2$ in $cd/m^2$ using the following relation:

$$1\ cd/m^2 = 10{,}8 \cdot 10^4 \cdot 10^{(-0{,}4\ [mag/arc\ sec^2])}$$

The marked points on the maps below (Fig. 9 and Fig. 10) represent the observation of the illuminated night sky. The lighter the point is, the lighter the sky is, the darker the point is the darker the sky [5]). The lightest point (magnitude 1) can be seen over the major cities. There, only few stars are visible in the night sky. The magnitude 7 can be seen over a national park for example, or outside the settlements, where there are not any city lights. According to Bortle Dark-Sky Scale there are few excellent dark-sky sites, where to the unaided eye, the limiting magnitude is 7.6 to 8.0 (with effort) and is possible to see more than 2000 stars at the same time [9]. When so many stars are visible, it is difficult to tell the constellations apart.


**Fig. 9:** Results from Globe at night campaign in 2012 from Macedoni.

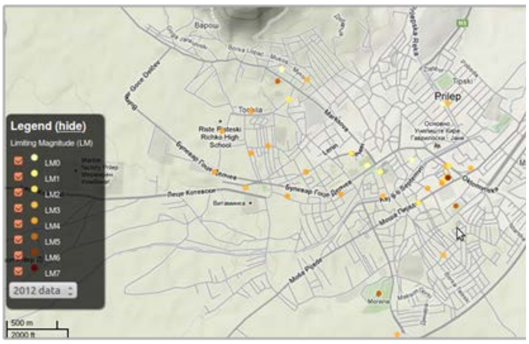


**Fig. 10:** Results from Globe at night campaign in 2012 from Prilep.

All the above-mentioned results then should be sent via Internet using the following web page: http://www.globe.gov/Gaiv/report.html during the Globe at night campaign or in the following two weeks. With our continuous observation we hope that we would contribute to the campaign against light pollution.

**Table 1:** The results from some of our recent observations:

| N: | Date | Local time | Long. | Lat. | Mag. | SQM -L value (mag/ arc $sec^2$) | Comment on location | Comment on the sky and cloud coverage |
|---|---|---|---|---|---|---|---|---|
| 11 | 2012/01/14 | 20:15 | 21.562 | 41.346 | 3 | 17,42 | The measurement is done on a parking in Prilep. There are two streetlights at a distance 50 m from my location. | No clouds. The sky is clear. Constellation Orion is visible. |
| 12 | 2012/02/18 | 20:58 | 21.534 | 41.345 | 4 | 17,37 | There is snow cover and air temperature below zero degrees Celsius. | 25% of the sky covered by clouds. Yet Orion is visible. |
| 13 | 2012/03/16 | 20:40 | 21.542 | 41.354 | 5 | 19,31 | Near the Faculty of Economy in Prilep. There are lights at 50m distance from my location. | Leo constellation is visible, but also the constellation Orion can be seen. |
| 14 | 2012/04/11 | 21:47 | 21.543 | 41.352 | 0 | 16,30 | Urban location | > 50% cloud cover, the Leo is visible. Not actually seen any astronomical source of light in the sky. |

## 3. CONCLUSIONS

Is light pollution important? When talking about astronomy, it negatively affects astronomical observations. Astronomy is rooted in history and culture and has practical applications. It contributes to the advancement of mathematics and computer science, science and technology. It is a dynamic science, and every year many of the most important scientific discoveries are in the field of astronomy or in related fields. It also has emotional and aesthetic dimensions, inspired many artists and poets for centuries. In school, it can be used to teach concepts such as light pollution, to give students meaningful appreciation for the scale of distance and time and to illustrate observational approach to the scientific method. Or, according the words of Henri Poinkare, ,,*Astronomy is useful because it shows how small our* *bodies, and how large our minds are*”. Light pollution is promising topic of promoting science education because it can be transferred in other science topics [3].

Measuring light pollution includes: astronomy activities (students investigate the effects of light pollution and other factors and estimate limiting magnitude of stars which they can see), physics activities (students use instruments, observe various natural and artificial light sources in their local environment), and science and society activities (students investigate the types of lighting in their community, the effectiveness of lighting and promoting better lighting in many different ways).

Our future plans with Globe at night campaign include the following: to continue with this program and measurements; to involve more students; to continuoue SQM measurements throught all year; to create new projects inspired from the GAN, etc.

From our experience, education is the first step in preserving the astronomical sky. In addition, the education takes place in variety of situations, outside the classroom. Non-formal education is an ideal way to educate people about the beauty of the night sky. In this direction, a campaign in the town of Prilep is planned in cooperation with the local authorities responsible for that issue. Our intention is to encourage others to take part in citizen science projects to measure light pollution, to write letters to the local newspaper and businesses and finally, to promote the use of compliant fixtures and shielding, which will lead to their installation in our community. Of course, for this purpose we will use the results of the measurements that were made last five years at various locations in the municipality of Prilep and the surrounding area. That does not mean that we have not informed the public yet, but the campaign is planned as series of many activities, on a higher level and with big number of inhabitants. We hope that it will help to consider the issue of the fight against light pollution in our country seriously and finally, to adopt of a law for dealing effectively with light pollution.

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# CASE STUDY ON THE INFLUENCE OF SIMULATIONS AND REAL EXPERIMENTS ON HIGHER ORDER SKILLS

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**Abstract** This research investigates the influence of computer simulations (virtual experiments) on one hand and real experiments on the other hand on the development of higher order skills, as well as the differences in those two approaches in the unit Electrical Charging.
The sample, which was investigated, consists of students in the second year of a gymnasium in Macedonia. There were two experimental groups and one control group. In one of the experimental group, the instruction was realized by means of computer simulations. In the other experimental group the instruction was realized by means of real experiments. The obtained results from both of groups were compared with the results from the control group, where traditional instruction was used. The same teacher performed the instructions in all of groups.
The pre-knowledge was tested with a pre test, as well as the acquired knowledge after the instructions. The same tests and analysis were performed with all three groups.
The results reveal that the approaches used in experimental groups give more quality knowledge and skills than the one in the control group.

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## 1. INTRODUCTION

The experiments have broad range of functions in reaching Physics. Theoretically, teachers express the fundamental role of the experiment during teaching and learning Physics.

Thus, instead of handbooks, that some times are compared with kitchen recipes, where usually students have to perform known procedures to express the physics Laws, it is requested to pass to the teaching and learning methods based on investigation, where the students are encouraged to recognize the problems, to build experiments by themselves and to analyze the results, which they did not know at the beginning, unlike in the case of traditional teaching. Shortly, the new methods try to put the students in a situation where they will think in the investigative, analytical and cooperative way, in a situation to decide and all that with practical and modern engaging.

Research and experimental work in natural sciences, particularly in Physics, keeps the students most of the time at the higher levels of thinking, i.e. students make analysis, synthesis, conclusions and so on. Thus, the students during the experimental work make analysis from the early beginning when they need to plan the investigation and make a certain sort of synthesis at the step of designing the investigation. So, when they obtain the results, they analyze again, which means they go back on the level of analysis, look for the relations, make conclusions, which takes them again to the level of synthesis and creation. This means that all the time, during the introduction, preparation and investigation, they go through this higher level thinking cycle. In this sense we offer them such activities.

In this direction, the computer represents a huge potential advantage. On one side the computer has already became a tool which cannot be substituted for scientific investigations, especially in Physics. But, on the other side, the application of the computers equipped with simulations also created possibilities for the improvement of the education process to a higher level, higher than that the traditional teaching allows.

On the other hand, the real experiments give quality that cannot be altered with anything else. The aim of this work is to discover which approach gives better understanding of physics concepts and stimulates higher level thinking. In order to investigate this, unit Electricity is taught to second grade high school students.

We decided to this research because most of the researches for understanding the physics concepts are done in mechanics [6], while in the other fields of physics this number is very small or no investigations have been done ([3], [8]). Therefore we think that there is need for research in other fields of physics, like electricity.

## 2. METHODS AND SAMPLES

### 2.1. The test

In this investigation the influence of the computer simulations and real experiments on higher level skills was examined. Test with 11 questions was used to measure the students' knowledge. First, pre test was used to measure the preknowledge. After the lectures, the students were post tested in order to measure the acquired knowledge. Delayed test was used 6 months later, to test the permanence of the acquired knowledge.

### 2.2. The sample

The sample consists of second year high school students from Macedonia. It was organized in two experimental groups and one control group. In the first experimental group real experiments were used and in the second experimental group computer simulations were used. The obtained results of these two groups were compared with those of the control group, in which traditional teaching method was used. The same teacher worked with all three groups. Also, with one of the experimental groups a delayed post testing was performed and compared to the post testing results taken directly after the lesson. The overall number of students that were tested is 115. From these 29 students were in the group with real experiments, 31 students in the group with virtual/simulation experiments, and in the control group 29 students. 26 students from the experimental group, with real experiments, were post tested.

Prior to the delayed post test, the students were given the possibility to discuss the post test results with their peers, without telling them which of their answers are correct or not. The aim was to investigate the influence of the peer-to-peer discussion on the knowledge.

## 3. RESEARCH RESULTS AND DISCUSSION

In this work only three of the eleven questions given in the test will be discussed.

In order to discover how much students understand the electrostatic interaction of electrically charged objects, the following question was given to the students:

Two light neutral metal spheres hang on a thread. They are close enough to interact, but they don't touch each other (figure 1). Make a draw for the following situations:

- Both spheres are electrically charged with a plastic rod that is rubbed with woolen cloth,
- The distance between the spheres is increased compared to the situation a),
- Sphere A is electrically charged with plastic rod that is rubbed with woolen cloth, and the sphere B is charged with glass rod that is rubbed with silk.
- Both spheres are electrically charged with plastic rod, but the sphere A is charged more than the sphere B.

The distribution of student answers is given in Figure 1.

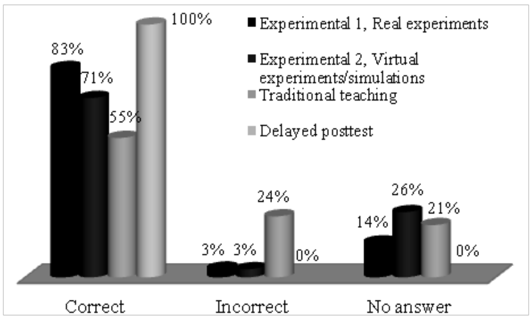



**Fig. 1a.**

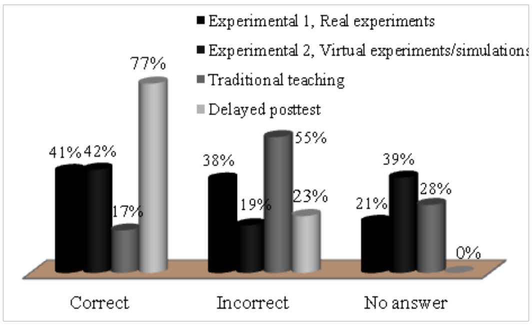



**Fig. 1b.**

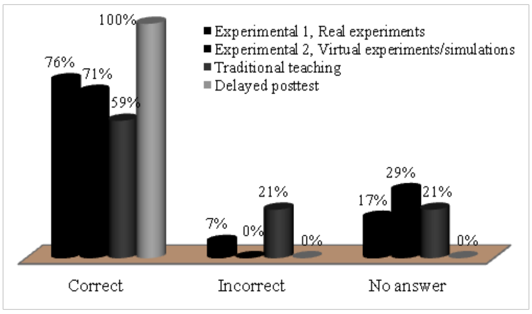



**Fig. 1c.**

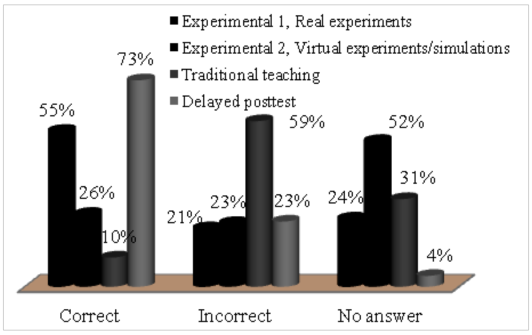



**Fig. 1d.**

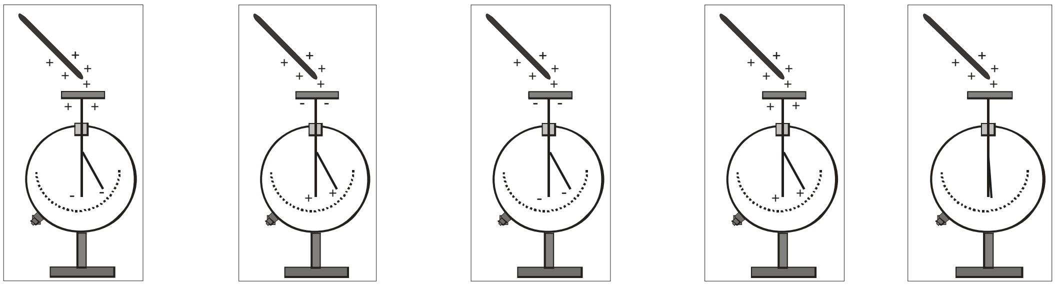
From the graphs in Figure 1 it can be seen that a higher percentage of students from experimental groups have answered correctly compared to the control one. Surprisingly, all students have correct answers at the delayed test. This means that teaching through previously prepared experiments compared to the traditional teaching gives better results.

The students from the experimental group working with real experiments achieved somehow better results than the one working with simulations. Each student had a chance to experiment and to see how the electrically charged objects set at a various distances interact with each other. We believe that this had huge influence on the knowledge they acquired.

Also, from figure 1 it can be seen that after the peer-to-peer discussion, the results are even better, because peer-to-peer discussion made the students more comfortable and free to ask about the things they did not understand. This is in agreement with result of other researchers [7].

The next question was to see how much do students understand the charging of objects by induction.

*A positively charged rod is placed near the head of an electroscope. Which picture describes this situation best? Explain the answer.*



**A** **B** **C** **D** **E**

The distribution of students answers are given in Figure 2.

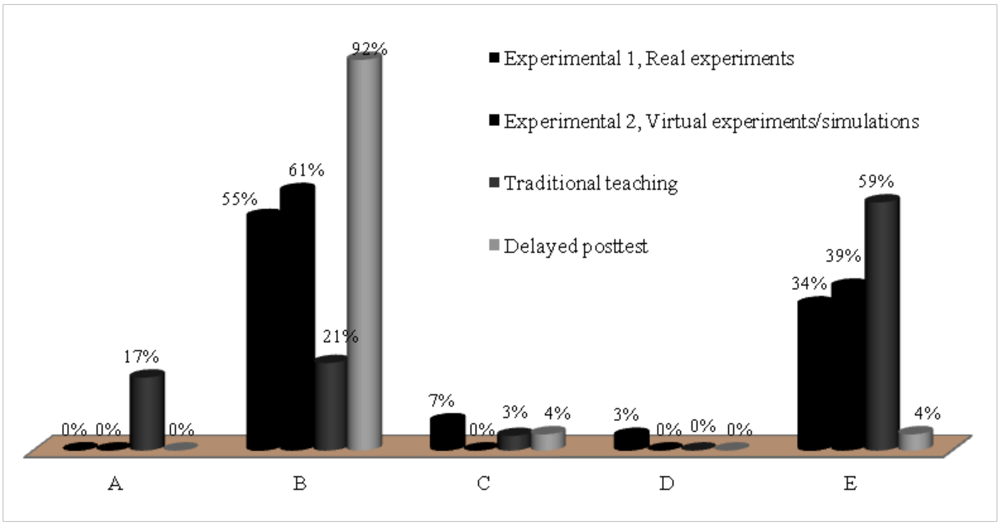



**Fig. 2.**

In order to answer correctly to this question the students have to know how the objects can be charged by induction and to apply this knowledge. As it can be seen from the graph, there is a big difference between the experimental groups and the control one. Students from the experimental did much better result than the ones in the control group. Unlike in the first question, more students from the experimental group with computer simulations gave correct answer, compared with the experimental group with real experiments (61% compared to 55%). The simulation has the advantage compared to the real experiment that can make the invisible things visible. In this case the electrical chargers in the simulation are visible. Therefore, the simulation is not anymore only a tool for research, additionally it explains the phenomena. Better result can also be consequence of possibility for individual work. Each student could individually perform the experiment.

As it was the case in the first question, the delayed test shows big number of correct answers, around 92 %, bigger than at the posttest.

Similarly to the previous question was the following one:

*One electroscope is negatively charged therefore its arrow shows a certain value on the scale. If a negatively charged rod is placed closer to the electroscope (without any contact), what will happen with the arrow of the electroscope? Draw the new situation!*

The distribution of students answers are given in figure 3.

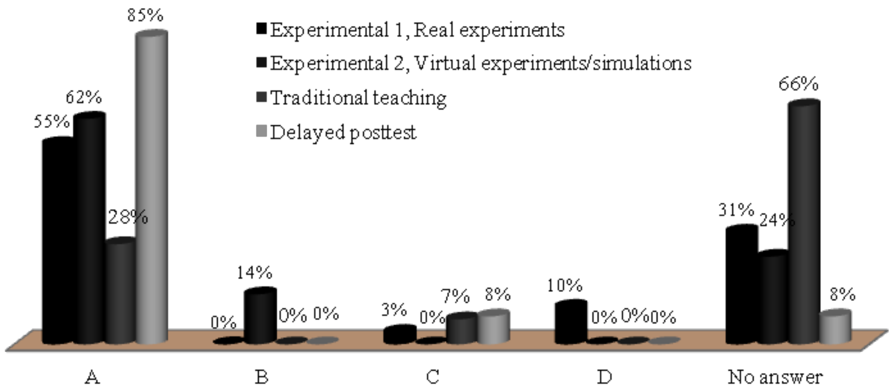



**Fig 3:** Legend: A – Increases; B – decreases; C – stays the same; D – will be zero

The results are similar to the ones in the previous questions. Here, the advantage of simulation, making visible the invisible things axplained in the previous question, is apparent again.. Again, the advantage of peer-to-peer discussion can be seen in the results of the delayed test.

## 4. CONCLUSIONS

The results from this investigation show that the teaching and learning approach applied with the experimental groups give better quality of knowledge and skills than the traditional one. Each of these approaches contributed differently, in the frame of characteristics they bring with them. For sure, they have overlapping of skills, like the development of the interacting and team work. The application of computer skills in teaching gives a better result in understanding of some occurrences for which the student does not necessary need to deal with the technique. But, this is negatively reflected on the knowledge and skills related to the organization of investigation work in the laboratory, in building an experimental setup and solving practical problems. On the other hand, the real experiment pushes the students to think more in the first part of planning and preparing experiments

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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.

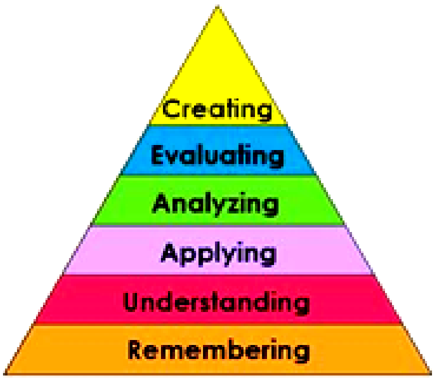



**Fig. 1:** Cognitive domain of Bloom's taxonomy

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.

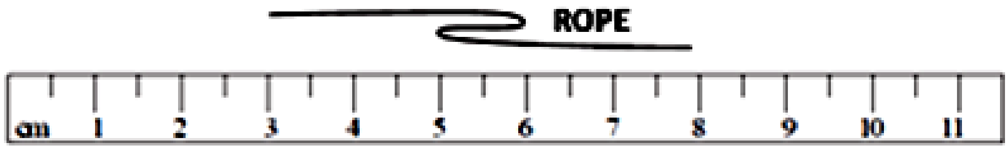
**Task 1:** *Is the calculation correct?*

$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

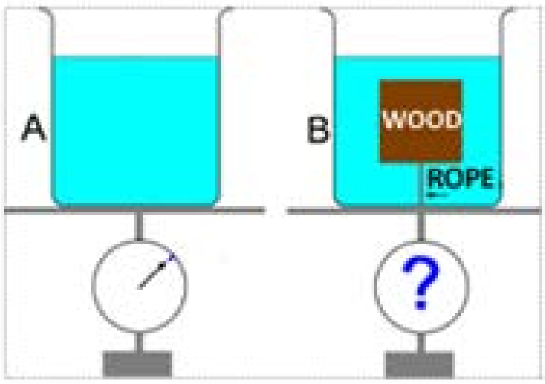
My expectations were that this task will be solved by all students. However, the results did not turn up as expected. Almost half of the students answered this question wrongly. Here are some of the students' answers:

- 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.

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# TO CLICK, OR NOT TO CLICK, THAT IS THE QUESTION

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**Abstract** This research deals with the high school students' response to involving new technology in the physics education. The goal is to measure the difference in the knowledge acquired with software for video measurement and without it. Using standard software for processing experimental data, Excel, the students focused their attention on where to click, instead on thinking about the results. This research presents the conditions in which this situation appeared.

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## 1. INTRODUCTION

When technology is used as a tool to support students in performing authentic tasks, the students are in the position of defining their goals, making design decisions, and evaluating their progress [1]. Video experiments are widely used in sports, crash tests, following of the fast processes in industry, and in the last few years (decades) in education. As computer technology develops, video measurements also develop.

Education is being partially transformed by new technologies. Today, the enormous amount of available information and even more, the increasingly rate of the information coming to the consumers, requires a transformative approach to education. It is imperative that the student of today learns how to be an information manager, rather than in information regurgitate" [2]

In this research two different approaches are used to measure the difference in the knowledge acquired by the students with video measurements supported by software and video measurement performed without software.

The first approach in video measurement uses Coach 5 as a software for supported video measurement (SSVM). With the Coach video data feature, various activities can be created for students to explore various motions. In the beginning the students have to set the frame of reference i.e. the axis and the origin, as well as the recording frequency. The experiment continues with many clicks on the moving object, during which the graphs and tables are automatically filled and drawn. During this process the students can watch how the curves in the graphs are “growing”. This gives students the opportunities to make a comparison between the trajectory and the graph.

The second approach uses video measurement without software, or in another words, manual video measurement (MVM). In order to perform this measurement, video player should be used, or software for video playback. We decided to use Media Player Classic. In this case, all values read from the video clip are manually imported in Excel by the students and calculated with the pre-imported formulas. Importing the formulas and calculating was done by the students, but with lot of help by the teachers. In order to measure the displacement, a meter stick is placed along the trajectory. The time intervals are measured from the recording frequency.

## 2. EXPERIMENT AND SAMPLES

The students had to investigate a free falling object and from these measurements, their task was to calculate the kinetic and gravitational energy in various positions as well as to discover the energy conservation law. The control group used SSVM, and the experimental group used MVM.

The sample consists of **eighteen** students from the first grade, high school, divided into two groups, experimental and control group, each of them with nine students.

Before they started with measurements they had a theoretical introduction about energy conservation law and briefly clarification about what they should do during the class.

During the classes the students from the experimental and control sample were given written instructions with detailed description of each step. In addition, the control group was given instructions how to import the values obtained by Coach in Excel in order to calculate gravitational and kinetic energy.

**Here are the details of the activities for SSVM group**:

1. Discover the relation between the velocity and time and position and time.

In order to fulfill this task, start the program Coach 5. Open the project Energy conservation law, and the activity Free fall. The video clip of the free falling object is already imported. Start the measurement by clicking on the green dot. Click on the moving object to measure the coordinates and the time. The program automatically reads the coordinates and time and imports them in table and graph. Repeat this procedure until the program comes to the last frame and turns off automatically (when the red dot becomes green again). The graph is ready to use. The students already know that the formula for the free falling object is $y = v_0 t + gt^2/2$ . In order to verify the formula and to obtain the coefficients (the initial speed and the gravitational acceleration) right-click on the graph, go to Analyze and pick Function Fit. In the field Function type select the function $y(x) = ax^2 + bx + c$ and click on the Auto fit. From the two options Add Graph and Replace Graph, select Add Graph. The velocity of free falling object is given by the formula $v = v_0 + gt$ . In order to verify this formula and to obtain the coefficients (the initial speed and the gravitational acceleration) right-click on the velocity-time graph and from the Function type select $y(x) = ax + b$ .

2. Calculate the kinetic energy for each position using the formula

$$E_k = \frac{mv^2}{2} \tag{1}$$

3. Calculate the gravitational energy using the formula

$$E_p = mgy \tag{2}$$

4. Calculate the difference between the gravitational and kinetic energy in various positions.

The students from the experimental group also got a written instruction with a description what they should do.

**Here are the details of the activity /instructions for MVM group:**

1. A free falling object is video recorded, with a meter stick next to the path of the object. The video clip is recorded with 24 fps. This means that the time interval between two frames i.e. between two consecutive positions is $1/24$ s.
2. 2. You are given an Excel document with prepared worksheet (Fig.1). Read the coordinates from the meter stick and write their values for the given time in the second column.

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | t (s) | y (m) | t2-t1 (s) | y2-y1 (m) | v (m/s) | tk (s) |
| 2 | 0 | | | | | |
| 3 | 0,04 | | | | | |
| 4 | 0,08 | | | | | |
| 5 | 0,12 | | | | | |
| 6 | 0,16 | | | | | |
| 7 | 0,2 | | | | | |

**Fig.1:** Worksheet that was given to the students.

3. Selected **XY scatter** from **Insert chart** and select the option **Scatter only with markers**. *X*-axe is standing for the time, and *y* is standing for the position. On any of the dots right-click and select the option **Add Trend line**. The theoretical formula is

$$y = v_0 t + \frac{gt^2}{2}. \tag{3}$$

In **Trend/Regresssion** select **Polynomial, order2**. On the same window select **Display equation on chart**. Polynomial, order 2 means that the curve is parabola.

4. The average velocity in interval $\Delta t$ is given by the formula

$$v = \frac{\Delta y}{\Delta t} = \frac{y_2 - y_1}{t_2 - t_1} \quad (4)$$

Calculate the time intervals $t_2$-$t_1$, and the position change $y_2$-$y_1$ in the corresponding columns [t2-t1 (s) and y2-y1 (m)] and use them to calculate the speed using the eq. (4). Insert the values for the speed in the corresponding column [ $v$(m/s) ].

The obtained value for the speed is average speed for every of the time intervals. That means that the speed value stands for the time $t_{21} = (t_2 + t_1)/2$

Insert this correction for the time in the corresponding column [tk(s)].

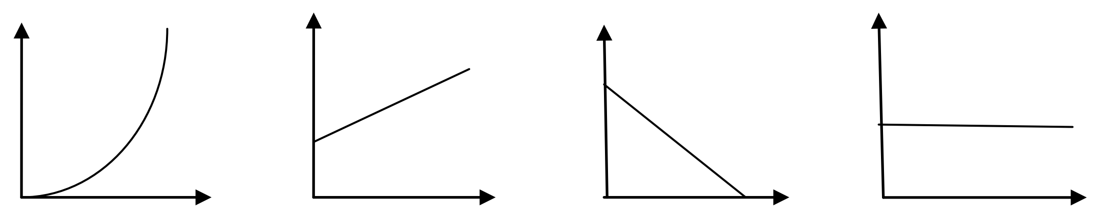
5. Construct the velocity – corrected time graph. The procedure is the same as for the previous graph. When selecting the **Trend/Regresion type,** select linear function. The calculation for the kinetic and gravitational energy is the same as the control group.

## 3. THE RESULTS AND DISCUSSION

In order to measure the change of the students' knowledge in the two groups the students were pre-tested and post-tested. The test consists of eight questions, each question testing different knowledge. Six of them were multiple choice questions, while two were open ended questions. The questions are based on the previous researchers' experience and other authors' experience [4, 5]. In the multiple choice questions, distracters are included in the offered answers. The same test was given at the pre-testing, before the video classes and at the post-testing, after the video classes. Therefore, the criterion is the same too. In this paper, the results from the last two questions, 7th and 8th, are given, which test the knowledge and understanding of the diagrams, which describe motion. In the seventh question, only one option is correct, and the goal is to see can the students recognize the object's motion from the shape of the curve in the position - time graph. In the last question, two options are correct, and the goal is the same as in the previous question. Students have to determinate the motion of the object by the shape of the curve in the velocity – time graph.

The 7th question is:

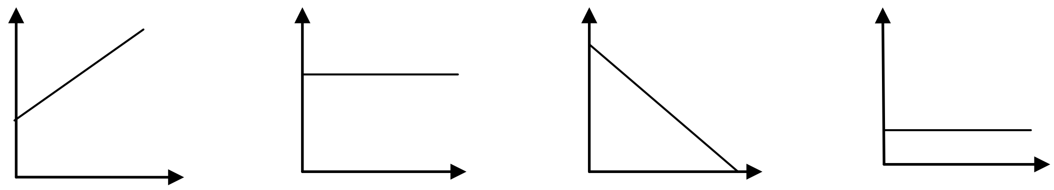
The four diagrams represent position-time graphs for four different objects. On which of those objects non-zero net force acts?



a) b) c) d)

The 8th question is:

The four diagrams represent velocity-time graphs for four different objects. On which of those objects non-zero net force acts?



a) b) c) d)

The distributions of the students' answers on 7th question from pre-test and post-test are given in fig. 3. Here, the students have to understand that if a non-zero net force acts on an object, then the object's motion is accelerated. This should bring them to the a) choice, which is the correct answer. The distributions of the answers show that big number of the students from the control group have chosen the correct answer on the pre-test, six students, while three students have chosen the b). But, at the post-test only two students have the correct answer and seven students have chosen the incorrect answer, b), which is a negative change. Other researches show that students do not pay attention on the quantities presented in the diagrams [5]. Weather it is position or velocity on the vertical axis it does not make any difference to the students. Sometimes they even explicitly change the quantity in the diagram. The shape of the graph in option b) is the same as the velocity – time curve for accelerated motion, which means that the students who do not have good understanding of motions and graphs, can easily be confused and mix up these diagrams.

Most of the students from the experimental group have chosen the correct answer at the pre-test, seven of nine. This does not give space for big change and at the post-test all of the students from the experimental group have chosen the correct answer.

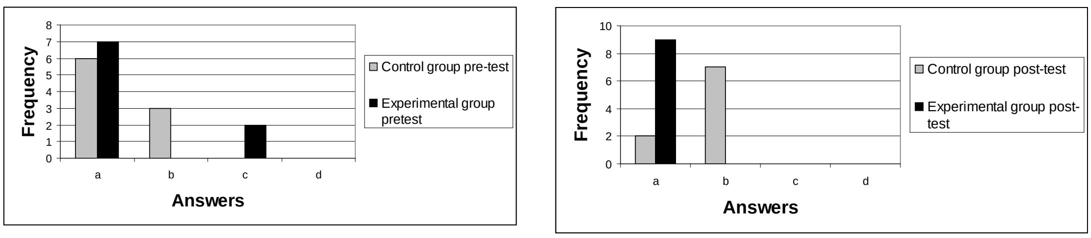
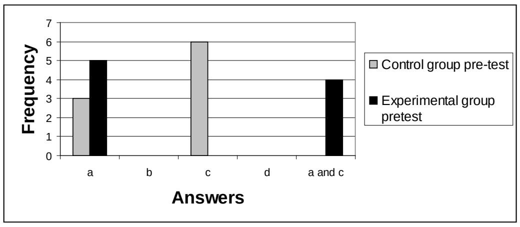



**Fig. 3:** Distribution on the answers of the seventh question on pre-test and post-test for control and experimental group.

The distributions of the students' answers on 8th question from pre-test and post-test are given in fig. 4. Here, the students have to understand that if a non zero net force acts on an object, then the object's motion is accelerated. This should bring them to the a) and c) choice, which are the correct answers. Unlike in the 7th question, here they have two correct answers. The a) represents accelerated motion and c) represents decelerated motion. The distributions of the answers show that the answers of the control group are distributed in the correct answers, but, there is not any student who gave the both correct answers. Later, ate the post-test, all students from the control group have chosen only the a) answer, which cannot be taken as positive nor negative change.

Five students from the experimental group have chosen a) answer at the pre-test and 4 students have chosen a) and c) answers, which is complete correct answer. Unfortunately, only two students have chosen the complete correct answer at the post-test. This shows the general problem with understanding velocity-time graph. Students understand position-time graphs easier, but when comes to the velocity-time graphs, additional activities are needed to overcome this problem.



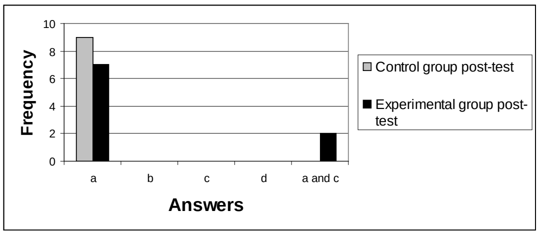




**Fig.4*:*** Distribution on the answers of the 8th question on pre-test and post-test for control and experimental group.

According to the results given in fig.2, the number of the students who answered correct to the seventh question is smaller on post test than the pre test for the control group. The experimental group has more correct answers on post test than the pretest.

As for the last question where two options were correct, we have to take in advance and the number of the students who chose only one correct option because the number of the students who chose the two correct options is too small. So for this question the number of students who decided for the option in which the shape for the velocity - time is the same as the shape which they get on the experiment is biggest for both groups.

## 4. CONCLUSION

The most of the students were focused on the problem where to click, instead on the results. The advantage of this approach is that students collect data manually so their conclusions and answers are based on their previous as well as new experience. Unfortunately, their previous experience with software supported video measurement or Excel is too small so this problem is transferred on their usage. Maybe if the students use longer Excel or manual video measurement as a tool they will show better results, which opens new subject for further research.

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# PHYSICS MISCONCEPTIONS IN SEVENTH GRADE

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**Abstract.** The goal of this research is to examine the understanding of basic physics concepts in Physics among 7th grade students in primary education. The results of the research reveal an interesting and bit surprising situation. Some common misconceptions occur, such as the one related to the concepts of mass and weight. Also, some new unexpected situations are discovered. A general conclusion is that students encounter difficulties in explaining these concepts. Students learn the concepts superficially and they do not understand them. The research also reveals a problem with the Macedonian vocabulary.

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## 1. INTRODUCTION

In science, words have to be accurate, clear and correct. Many times a lot of international concepts are being used, which sometimes, because of their inadequacy and limit in translation, may cause problems in the scientific communication. A lot of scientists and teachers try to introduce the science to the younger generations through determining the scientific concepts, by choosing the descriptive way, trying to express them in Macedonian words.

We know that the studying, or the process of acquiring knowledge, is one of the ways of the cognition of the external world. In the knowledge, a lot of phenomena and objects from the everyday life, their properties, relations and laws that they are submitting to, are being expressed. As its results, the students are form perceptions, concepts, judge and make logical conclusions.

The main goal of some teachers is fulfilling obligations towards curriculum, i.e. running with the students through as more concepts and contents as possible, without considering the way these processes are being done and the depth of the acquired knowledge.

One of the main goals in the teaching Physics is correct and proper way of understanding the physical concepts ( the first and the second level according to Bloom), their application (the third level according to Bloom) and their proper use in new and unknown situations ( higher levels according to Bloom) [2].

However, what does ***the concept*** mean? ***The concept*** is defined as “a thought or an intention; something that we realize; something that’s made up in the head; an abstract idea that’s being generalized with specific events” (Webster's Dictionary) [3].

Researches through the history have shown that no matter what is the achievement, in physics it иs not only about working on learning the teaching material and success in solving specific problems, but in most cases it depends on the students abilities to make statements and to use their ideas in a clear and accurate way.

To understand the essence of a subject, proper understanding of the basic concepts, which form the foundations of that subject, is of crucial importance. This research is trying to find out the level of the students abilities to form an image about the concepts, to explain their views, thoughts, interests and understanding of some physics concepts.

## 2. THE RESEARCH

**The main goal of this research is to examine:**

1. How and how much seventh grade students understand physics concepts.
2. What are the most common misconceptions for certain concepts that students have?

The research includes 35 concepts. Some of them like trajectory, atom, joule, inertia, weight and others are studied for the first time in seventh grade, while others like mass, volume, meter, state of aggregation and others are previously known. All of them are provided in the seventh grade curriculum, in the following topics:

1. Bodies, substances, physical quantities and measurement of physical quantities
2. Motion and forces
3. Energy

In order to achieve the goals of this research, a questioner was given to the students, where the students had to choose their level of knowledge of a certain concept. An example of a concept and the levels of knowledge are given in Table 1. Students could choose two options for each concept between “I can’t explain” and “I’m explaining it like this…” In the last column, the students had the chance to explain the concept. They could use small drawing, chart, formula, synonymous or something else.

The examination is conducted during a physics class with duration of 30 minutes.

**Table 1** *An example of a question in the questioner*

| A given concept | It is the first time I am hearing of this concept | I have heard of this concept before | I cannot explain this | I am explaining it like this … |
|---|---|---|---|---|
| Mass | ✓ | | ✓ | |

58 students with various abilities are included in this examination. 17 students are from urban environment and 10 of them are excellent students. 41 students are from rural environment and 12 of them are excellent students. That means that about 38% of the students that were included in this research are excellent students.

Very simple explanations of the concepts were considered correct. For example:

1. Mass- quantity that is measured in kilograms" or "quantity which can be measured with scales,
2. Aggregate state - can be liquid, solid or gaseous…

## 3.RESULTS

1. Over 95% of the students have heard about the concept of ***mass***, but only 13,8% of them can explain it. That means, although this concept is clear to them, it cannot be explained even by the excellent students. Although they knew that it is something related with physics, this concept, for a less than 1% of the students, is an association for ***a dining table!!!*** (there is one word in Macedonian for mass and for dining table).

2. 32,8% of the students explained the concept of **aggregate state** and that's one of the concepts that students understand more;

3. The concept of ***inertia*** is explained by 31% of the students. But, the definition they gave was like "reciting" the definition from the textbook, so there is an impression that they did not understand this concept.

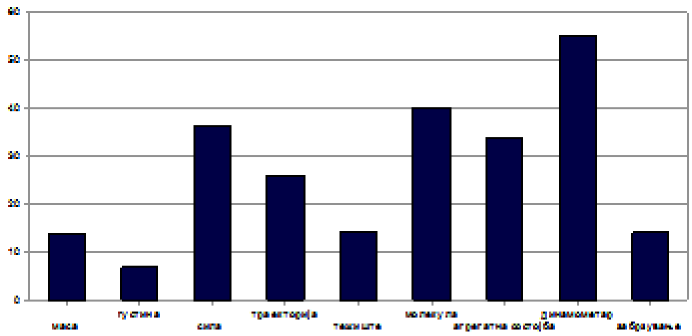


**Fig. 1** Distribution of the correct answers and explanations

4. The concepts of ***elapsed time*** and ***physical quantity*** are being explained only by 0.5% of the students…

5. The concepts of ***meter, joule, Pascal and other units*** are defined as *units of length, mechanical work, pressure, etc.*, respectively and these answers are accepted as correct. Only two of the students, for the concept of *meter* gave the answer "*basic unit of length"*, and two of them for the concept of *joule* wrote 1J=1N*1m

6. The concept of ***plasma*** (the fourth state of aggregation) is not being studied in seventh grade. This concept was mentioned only in the additional instructions and that's why it wasn't expected for the students to recognize it.

7. The concept of ***volume*** is studied in the lower classes and mainly "it is known" to all of the students. But only one of them gave a definition like this: *"space occupied by the body"*.

8. The concept of ***density*** was explained by 6.9 % of the students, and most of them only wrote a formula!

9. The concept of ***power*** was explained by 41,2 % of the students.

10. The concept of ***mechanical work*** explained only 14% of the students.

11. The concept of ***kinetic energy*** was explained by 48,3 % of the students.

The research was done after learning of the last content of the topic about ***Energy*** , so that is why student remembered more the concepts related with this topic, but the level of recognition is still not satisfying.

## 4. DISSCUSION

Besides correct answers, there are many misconceptions discovered in the incorrect answers. Some of them are standard and common, while some of them are new.

1. **Mass -** Body weight, measurement of body weight; how heavy one body is;
2. **Acceleration-** Movement with great speed; how fast we move;
3. **Volume-** Shape of a body; size of a body;
4. **Gravity-** Attraction of two bodies with huge masses; a force that the Earth is attracting bodies with;
5. **Gravity-** Exists between the bodies that fall down;
6. **Average speed-** Arithmetic mean of speeds;
7. **Trajectory-** distance travelled by the object (GAP phenomena – Graph as a picture);
8. **Fluids-** liquids;
9. **Center of gravity-** There is a wrong definition in the textbook. The students learned this definition. Teacher should point up this mistake!!!!)
10. **Speed and acceleration-** it's the same thing.

Misconceptions can originate from various sources. Beside the knowledge that's acquired in the informal education by interacting with the surrounding outside the school (family, media, street and others), the student in seventh grade comes prepared with knowledge from the previous grades, from first through sixth grade. In that process, the teacher and the textbooks can be very important factor in building misconceptions. Teacher who teach in the lower grades of elementary education (from first to fourth grade) obtain their degree at the Faculty of education or at the Faculty of Philosophy – pedagogy studies. The first ones during their studies have never attended a science subject, or they have, but only during one semester and it has limited areas (mainly in Biology). The second ones did not attend science subjects at all. That is the main reason why their understanding for the concepts from the sciences and the Physics is on a very low level. This is a very important thing to mention because in mathematics curriculum for lower grades, there is a section provided for working with data. Most of the data the teachers and students use are related to physics concepts, such as mass, length, speed, movement etc. During these lessons, insufficient knowledge and understanding of physics concepts and incompetence of the teachers is expressed the most. A proof for that is the result from this research that shows that the misconceptions are less present in some concepts that are mentioned for the first time in seventh grade, for example *instantaneous speed, kinetic energy and uniform motion,* then in concepts like *mass, volume and meter,* which are studied in the lower grades. This effect is expected to be even bigger with the introduction of the new science subjects, such as Nature, Natural Sciences and Natural Sciences and Technique in fourth, fifth and sixth grade, respectively, because there are not teachers who are familiar with all of the science, but only with sections of it.

Mistakes in the textbooks can generate misconceptions, as well [1]. That is the case with the definition of the center of gravity, where students answer that the center of gravity represents the “point where the vector of the weight acts”, which is wrong answer that’s given in the current Physics textbook (page 66). Of course, in this cases, the role of the teacher is very important as a last filter that has to correct all of the mistakes, illogical things and inconsistencies in the textbook, the curriculum, grading standards and all of the other acts and documents that are related to the immediate implementation of teaching.

At first sight, it sounds shocking that a very small part of the students can explain the concept of ***mass***, besides the fact that they have meet that concept in the first grade, But that’s not strange at all, because it is just a standard misconception that face students from another countries, too [5,6]

The results from this research show that the students with lower GPA have misconceptions, as well as the excellent ones.  Trying to change the first impression of the misconceptions, the teacher is facing this unexpected situation: “I can’t believe that this happens in my class…” (Piaget 1965), and this “cognitive conflict” occurs, between what the teacher requires from the students, and what is “the reality” in the class! [4]

Besides all of the things that were listed above as the reasons for misconceptions development, there are some others, too. Other reasons can be:

1. New concepts are studied shallow, without any deeper explanations, so they stay abstract even in the higher grades.
2. The students are not interested in studying new concepts.
3. Students have very poor scientific vocabulary, and even when they know the concept, they cannot explain it.
4. The curriculum is structured in a very crowded way, which does not allow thorough studying new concepts.

## 5.CONCLUSION

Learning new concepts is mainly based only on the first level of the Bloom’s Taxonomy – **memorizing**, and that is where it ends.

The students mentally “cannot” or they are not interested for the higher levels in the process of studying, such as understanding and applying, or even less for the examination from higher level such as analysis, synthesis, evaluation or creation. That is why more attention should be paid to the processing the new concepts, to integrating the curriculum so there will not be any obstacles during the studying, previous knowledge that students posses should not be contradictory and incomplete, and the first image that the students get for the concept to be appropriate to their intellectual ability. New methods and techniques of studying are necessary, so that the students get more involved and interested in it. Also, it seems that the teacher pays more attention and is more successful in making the choice and applying a formula, rather than making a correct image of the concept and its understanding.

We need a big, complex and long-term research, which will show the necessary concepts that students need to master at a certain age. It also has to find the connection and the compliance with the curricula of different related subjects such as Mathematics, Physics, Chemistry and Biology. Time required to introduce new concepts should also be one of the important elements of such research. The results of such research will be introduction into a reform in science education. That will let the students easier and better to overcome the concepts in Physics and other sciences, because a lot of them are interconnected.

A very important moment is the choice of the teachers that will perform classes. There have to be provided regulations that will regulate the choice of the teacher to teach the appropriate classes.

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# МИСКОНЦЕПЦИИ ОД ФИЗИКА ВО СЕДМО ОДДЕЛЕНИЕ

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**Апстракт:** Зборовите и поимите кои се употребуваат во науката мора да бидат прецизни, јасни, еднозначни и точни. Многу често се користат странски зборовим кои поради ограничувањата во преводот и неадекватноста, воведуваат нејаснотии. Во процесот на поучување, многу наставници се трудат да одговорат на обврските на реализирање на обемната наставна програма, не обрнувајќи внимание на квалитетот на стекнатото знаење и покрај тоа што една од главните цели во наставата е учениците да се здобијат со квалитетни и коректни знаења и да можат тие да ги користат во нови ситуации. Се разбира, важен момент е и развивањето на способностите на ученикот за искажување на своите мислења и знаења.

Ова истражување има за цел да открие колку учениците од седмо одделение ги разбираат физичките поими и кои се најчестите мисконцепции. За таа цел на учениците им беше даден прашалник, во кој беа наведени повеќе физички поими. Учениците можеа да одбираат помеѓу "прв пат слушам за овој поим" и "сум слушнал за овој поим". Од друга страна, од нив се бараше да го објаснат поимот. За таа цел им беше дозволено да користат формули, цртежи, зборови и се друго што ќе им помогне да го објаснат поимот. Тие можеа да го објаснат дури и преку единиците или постапката за мерење на соодветната физичка величина.

Резултатите покажуваат дека, преку 95 % од учениците слушнале за маса, но само 13,8 % од нив успеваат некако да го објаснат. Нешто е подобра состојбата со поимите за агрегатна состојба и инерција (го објаснуваат околу една третина од учениците). Поимот за густина го објаснуваат само 6,9 % од испитаниците.

Исто така се појавуваат и некои стандардни, но и некои нестандардни мисконцепции: маса-тежина, забрзување-движење со голема брзина, волумен-облик на телото, патека-изминат пат.

Извори на овие мисконцепции се предзнаењата во текот на наставата по математика во пониските години од основното образование, чиј корен треба да се бара во недоволната подготвеност на тие наставници. Овој проблем може да дојде до израз уште повеќе со евентуалната несоодветност на наставниците по Природа, Природни науки и Природни науки и техника. Овој резултат укажува на големата важноста на наставникот. Извор на мисконцепции се и грешките во учебниците, како онаа за тежиште. Еден од поголемите проблеми е и сиромашниот физички речник на учениците, но и речник воопшто.