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FORMATIVE VALUES OF PROBLEM SOLVING TRAINING IN PHYSICS*

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Abstract. Problem-solving is a dynamic principle of methodology designed to enrich students' activity. Dealing with real problems directs students' thinking process towards researching and acquiring new knowledge. Teaching by problem-solving ensures an active and interactive involvement of the students in the teaching process. In this paper, we presented the contribution made by the problem-solving teaching in Physics as far as developing students' cognitive and creative abilities is concerned, as well as in increasing their desire to study Physics more, beyond the limits of the school curriculum.

Key words: problem solving, problem based learning, physics of real world.

1. INTRODUCTION

The contemporary society is a problems-generator whose solution requires creative personalities, capable to elaborate ideas and to apply them into practice in order to adapt to the fast rhythm of the current changes. These objectives are achievable only when each member of the society assimilates some creative strategies that could be transferred to any situation, in varied domains. One of the most important goals of the modern education is to educate individuals who can easily solve the problems which they encounter [1].

The instructive process should be oriented towards the formation of creative capacities in students by structuring a continuously problematized learning. The essential element of the problematized instruction is the elaboration and resolution of the problem-situation. The problem-situation represents the contradictory state between the student's previous experience (knowledge, capacities and attitudes) and the unknown that he has to face. It appears because of the intellectual conflict

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between what the student knows and what he does not know, between what he can solve and what he has to solve [2–4].

Getting students involved in problematized situations is opportune when:

- ✓ there is a disagreement between the previous knowledge and the requirements imposed while solving a new problem;
- ✓ students face a contradiction between the resolution of a problem from the theoretical point of view and the impossibility to apply this into practice;
- ✓ students are asked to apply their previous knowledge in new conditions;
- ✓ students have to choose from a knowledge system only what is necessary to solve the given situation [4].

The modern didactics recommends the creation and resolution of problem-situations because they are considered to be the most productive learning processes. This is due to the fact that they activate students, amplify their desire of knowledge, stimulate inventiveness and the update of previous experiences and prepare students for solving life problems. A problematized teaching-learning process is achieved through tasks like: question–problem, problem and situation–problem [5, 6].

A logical consecution between old knowledge and knowledge about to be discovered is absolutely necessary. In order that the student should not be psychologically blocked, some aspects must be taken into consideration. Firstly, the difficulty level of the problem should not exceed the student's development level. Secondly, the content of the problem should be connected to practice and to the student's life, and should motivate him intrinsically. Also, the problem should have a divergent character, meaning more resolution alternatives and more possible solutions. Finally, the problem formulation should be attractive and arouse positive emotions and the desire to explore the unknown [7–9].

According to D.Ausubel and F.Robinson, problem solving is learning by discovering, a complex process placed between the application of knowledge and creativity in the behaviour hierarchy. Moreover, what appears to be a problem for one student, for another one it may only be a simple application, since some solutions contained in the student's previous experience are resumed [10].

Problem solving is an investigation task whereby the solver explores the solution path to reach a goal from given information. Also, problem solving is a complex multi-layered skill and not one which the most students can be expected to develop unaided [1]. Teaching by problem-solving ensures an active and interactive engagement of the students in the teaching process.

In this paper, we presented the contribution brought by the problem-solving teaching technique in Physics as far as developing students' cognitive and creative abilities is concerned, as well as in increasing their desire to study Physics more, beyond the limits of the school curriculum.

2. LEARNING PHYSICS BY PROBLEMATIZATION

Learning by problematization represents the way in which students can take part actively and interactively to the didactic process. This consists in projecting and caring out activities of independent, individual or collective search for the answer to a problem [11].

Problematization includes knowing and understanding the data of the problem, reorganizing the mental or practical behaviour and formulating the hypothesis, working out the solving plan and discovering the best solution, verifying the respective plan and solution.

Solving a problem begins with its initial formulation – stating the problem. The definition of the task and of the starting point begins with awareness. If the student has relevant knowledge, he will be able to relate the problem with his cognitive structure and therefore to understand the nature and the conditions of the issue he is facing. The strategy of solving problems represents a set of rules of selecting, of establishing the primary order, of combining, modifying or operating in a different way with the fundamental information [3, 8, 12].

The entire process can be more efficient through self-questioning. This method consists in asking varied questions, from unexpected perspectives. Consequently, a wide frame is created, multiple aspects are revealed and students are incited to investigate and explore, while answers are suggested [13, 14]. Issuing hypotheses depends on imagining the possible alternatives. This is the climax of students' creativity [15].

By analyzing the teacher-students interaction during the creation and resolution of the problem-situation four levels of problematization are identified.

At the first level the teacher states the problem and shows the students how it can be solved. They notice and analyze the teacher's explanations and his way of acting, and they can also ask some clarifying questions. However, their activity is mainly reproductive.

At the second level the teacher creates the problem-situation and through a system of questions he leads his students in order to issue and check the hypothesis. The students apply their reference knowledge in a new situation and look for other methods to solve.

At the third level the teacher creates the problem-situation and the students resolve it independently: individually, in pairs or groups. In order to find the necessary information they turn to their textbooks or other sources, generate solutions and analyze them, select and present their answers. This process implies an increased level of independency in resolving the problem-situation.

At the fourth level the students themselves formulate the problem and resolve it individually or in groups. This level corresponds to the principle of individualization and differentiation of the problem solving process. Here we integrate individual work, imagination, logical thinking, the discovery and argumentation of the solution, and the illation [2, 4].

The method of solving Physics problems is used to reinforce, fathom and enlarge knowledge. The teacher has to carefully choose the problems he brings up to his students, assuring enough diversity, with typical and representative situations which should refer to the whole given chapter. It is not recommended to reinforce some knowledge by endlessly repeating calculation algorithms. The teacher should prevent students from solving mechanically by making simple analogies or randomly applying the formulas [16].

Physics problems are used to create problem-situations and state the topic, to communicate new information, to form and develop intellectual abilities, to check the level of understanding, to reinforce, generalize and review the knowledge and to develop students' creativity.

Physics problems relate to large areas of both theoretical and practical situations and ideas, becoming not only an important way to fathom, but also an instrument to assess/self-assess the quality of learning.

Physics problems can be classified according to the following criteria: the type of the tasks (to calculate the unknown quantities, to demonstrate, to construct), the content (simple, mixed), the method of presentation or resolution and purpose (of training, of cognition, of creation) [8].

An important feature of the Physics problems is their complexity and difficulty level. The psychologists consider that the complexity level of a problem depends on the way in which the tasks regarding the use of previous knowledge are formulated and on the clarity with which the general to be used while solving is enounced. On the other hand, the methodists consider that a problem is complex if its resolution requires solving directly a series of simpler problems.

A difficult problem is a complex problem whose division into simple problems is not obvious. The complexity of the problem is determined by the rapport between the problem and the solver. The difficulty is caused either by the fact that the student does not have enough knowledge to transpose the problem statement into formulas, or the fact that the student does have enough knowledge but he cannot understand the essence of the problem, nor establish the mathematical relations between the given Physics quantities. During the teaching-learning activity, the teacher has to come up with more and more difficult problems. If the student cannot solve a certain problem, than it is the teacher who should suggest a system of helping problems with a lower difficulty level [4, 7].

Solving problems is the predominant traditional approach in teaching Physics. There are no preset patterns for solving all the Physics problem. The variety, the new scientific discoveries and the continuous appearance of interconnections between different domains of Physics are arguments against setting some inflexible calculation programs. Yet, the one who solves a Physics problem has to follow some steps: analyze the content and extract calculation elements, convert into equations, solve, present the solution and analyze the statement and the stages got through [8]. Unfortunately, many students just are trying to memorize formulas and results. But if they do not understand the phenomena, it is unlikely that they will correctly solve a Physics problem by themselves [17].

3. SOLVING REAL LIFE PROBLEMS

Solving problems is one of the main instruments for studying Physics and it is essential to achieve the scientific goals of explaining, predicting or elaborating [4]. There are three directions which imply the word "problem": problematization, problem solving and problem-based learning.

3.1. THE PROBLEMATIZATION

The problematization consists in creating a problem-situation whose solution should be the result of the research activity done by the student individually. The concept of "problem" thus signifies a doubtful sentence which can have more solutions, a contradictory situation meaning a conflict between previous experiences and the novelty the students faces [3].

Example 1: "Why does a driver gradually slow down when he wants to stop his car in a certain place?"

3.2. THE PROBLEM-SOLVING

Traditionally, problems are used in Physics lessons in order to transmit and acquire new information, to create intellectual and practical abilities, to review, systematize and assess knowledge and skills [4]. In this case, the "problem" is regarded as an application, confirmation, verification of some rules previously acquired [3].

The stages of solving a Physics problem differ from one author to another. Reif proposes three major steps: initial analysis, construction of a solution and checking the solution [18]. Heller proposes 5 steps: visualize, describe, plan a solution, execute and evaluate [19].

The impact produced by the way in which the problem is presented has direct consequences on students' motivation for finding a solution and on their engagement in approaching the given problem from multiple perspectives.

In textbooks and problems sets the most frequent form of presentation is the following – characterized by a high level of abstractization and generalization.

Example 2: "An object of mass 60 kg is at the top of a slope of 30-degree inclination, initially at rest. It begins to move downhill under influence of gravity and travels 50 meters on the frictionless surface before the surface becomes level.

The level surface is frictionless for 10 meters, and then has friction. If the object is to stop in less than 20 meters from the point where it leaves the frictionless surface, what must the coefficient of friction be?” [20].

It has been noticed lately that describing a real life situation has better chance to engage students in solving the problem, even if this kind of approach requires a longer time and more resources.

Example 3: “Your friend has just been involved in a traffic accident and hopes that you can show the accident was the other driver’s fault. Your friend’s car was travelling north when it entered the intersection. When it reached the centre of the intersection, the car was struck by the other driver’s car which was travelling east. The two cars remained joined together after the collision and skidded to a stop. The speed limit on both roads is 50 mph. From the skid marks still visible on the street, you determine that after the collision the cars skidded 56 feet at an angle of 30 degrees north of east before stopping. The police report gives the make and year of each car. The weight of your friend’s car is 2600 lbs and that of the other car is 2200 lbs, including the driver’s weight in each case. The coefficient of kinetic friction for a rubber tire skidding on dry pavement is 0.80. You decide to see if the other driver was speeding and if your friend was under the speed limit.” [21].

By analyzing the problem statements in the two examples we can notice there is a difference between their formulations. The example 2 is traditionally conceived, while the example 3 brings up a real life situation. This type of problems, Context-rich problems (CRPs), are more and more presented both in learning and assessing Physics, and many studies recommend they should replace the classical problems.

CRPs are short, realistic scenarios which ask students to use their theoretical knowledge in order to decide upon real situations, thus offering them a motivation to solve the problem [19].

One way to invent context rich problems is to start with a textbook exercise or problem and modify it. The following steps are recommended when designing this kind of problems:

- Always start a context rich problem with "You." This personalizes the problem and motivates the students.
- If necessary, determine a context (real objects with real motions or interactions) for the textbook exercise or problem.
- Decide on a motivation.
- Determine if you need to change the target variable to make the problem more than a one-step exercise, or make the target variable fit your motivation.
- Write the problem like a short story. (Optional)
- Decide how many "difficulty" characteristics you want to include.
- Check the problem to make sure it is solvable, the Physics is straight-forward and the Mathematics is reasonable [22].

Any classic problem can become a context rich problem if it is formulated. A very efficient exercise in shaping real life situations, but also in understanding Physics notions is turning a classic problem into a context rich one. In this way, CRPs offer students the opportunity to develop problem-solving skills which they can apply in the real world. By engaging in this type of problem solving, students develop expert-like thinking in the discipline.

Context-rich problems have the following benefits for students:

- support the development of a logical problem solving framework;
- encourage students to use expert problem solving strategies;
- increase the level of sophistication of the way students think about their world; provide practice in applying the fundamental concepts of the discipline;
- help students progress towards expert-like thinking [19].

3.3. THE PROBLEM-BASED LEARNING

The classic definition of the problem-based learning (PBL) is learning resulting from the process run to solve a problem. The ground of learning by solving problems consists in creating problems connected to real life that students should work out in small groups. PBL can be considered as a sum of six dimensions in approaching learning: conceive the problems, activities for small groups, compatible evaluations, curriculum development, knowledge and skills enlargement, optimization of the teaching-learning process [23]. The PBL approach is more demanding with the achievement of competencies than the traditional system [24].

A basic premise of problem-based learning is that students take greater responsibility for their own learning, with the benefit that they develop a wider range of transferable skills such as communication skills, teamwork and problem-solving. At the same time, through problem-based learning, students perform just as well in examinations, but develop slightly better reasoning ability and have consistently higher levels of satisfaction. Within the problem-based learning context, problems are invariably defined as “ill-defined” and “real-world”, pointing out that they are artificial abstractions specifically constructed to facilitate student learning [25].

It is recommended that the following steps should be taken in Problem Based Learning:

1. Identify the problem;
2. Explore pre-existing knowledge;
3. Generate hypotheses and possible mechanisms;
4. Identify learning issues;
5. Self study;
6. Re-evaluation and application of new knowledge to the problem;
7. Assessment and reflection on learning [26].

In specialty literature there are identified numerous advantages of PBL: it favours the application of solving problems in new situations; it stimulates critical and creative thinking; it allows the identification of strong and weak points in learning; it encourages collaborative and self-directed learning; it stimulates the development of communication skills and it involves the use of varied and relevant resources [27].

"A Day in the Life of John Henry, a Traffic Cop", the example suggested by Barbara Duch for using PBL at Physics confirms the formative valences of this method compared to the traditional ones.

Example 4: "At 1:20 p.m. on the last Friday in September 1989 a frantic call was received at the local police station. There had been a serious automobile accident at the intersection of Main Street and State Street, with injuries involved. Lt. John Henry arrived at the scene 10 minutes after the phone call and found that two cars had collided at the intersection. In one car, the driver was unconscious and in the other car both the driver and one passenger were injured.

After the emergency vehicles transported the injured to the hospital, Lt. Henry's responsibility was to investigate the accident in order to determine whether one of the drivers was or both were responsible." [28].

The sketch of the accident scene is shown on site http://www.udel.edu/pbl/curric/acc12a.html. Here, a lot of questions guide the student in solving this problem, at least partially. We present just some of them: "What questions does John Henry have to answer in this investigation? What measurements does he need to take? What data should he collect? What other information does he need to record in order to aid the investigation? What physics principles will John Henry need to use in order to help analyze the data and answer his questions? If two cars moving at right angles to each other collide, in what direction do you expect the cars to be moving after the collision? Why would John Henry note the weather and the condition of the road?

Duch considers that at the end of this step, students should be able to:

- use understanding of the principles of forces, motion and energy to design a plan to reconstruct the car accident;
- explain how frictional forces related to varying surfaces affect the motion of an object;
- calculate the velocities of two vehicles before and after impact using physics principles, such as forces, motion, mechanical energy and conservation of momentum;
- evaluate real world data related to a car accident in order to make a judgment about the drivers' fault;
- find and use appropriate learning resources to aid in reconstructing the accident [28].

4. USING PBL IN STUDYING COLLISIONS

The study of collisions is one of the lessons which have roused students' interest. But their motivation for fathoming this theme decreases proportionally with the complexity of the approached problems, even if the justification is a better shaping of reality.

Questioning 143 9th-form students on the difficulty faced while studying Physics, they answered like in chart presented in Fig. 1.

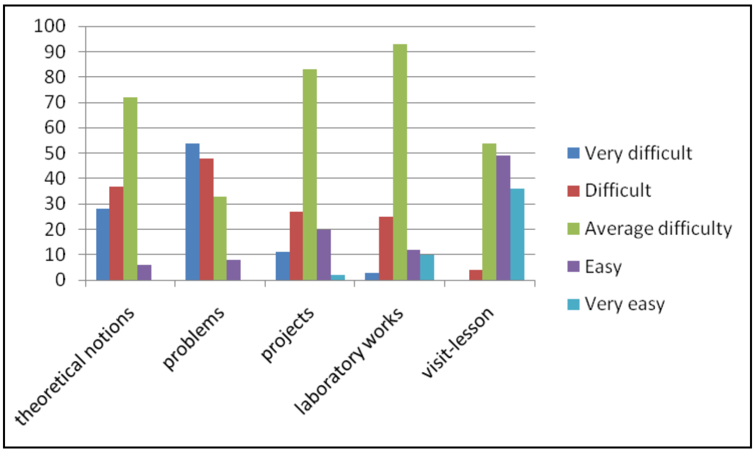

Fig. 1 – The difficulty faced by students in the study of Physics. The colored versions could be accessed at http://www.infim.ro/rrp/.

To overcome this problem, the students were asked to identify situations in which collisions are met, situations that could become tasks to be solved in this chapter. Among students' propositions, traffic (especially accidents) and sport (tennis, billiards) examples stood out.

In order to get out of the rigid framework of classical method to solve problems, this activity was organized as a PBL. A group of students came up with the problem for the rest of the class. The highest risk was that the proposed tasks be too difficult or require Physics and Mathematics notions more complex than the students had at that moment. This was the case for the most spectaculous problem students proposed, which approached the PIT maneuver. They considered that the impact between the car which was pursuing (bullet) and the one being pursued (target) is sufficient to classify this maneuver as a collision.

4.1. THE PIT MANEUVER

The Precision Immobilization Technique or Pursuit Intervention Technique (PIT) is a maneuver through which a car can force a fleeing car to nudge sideways, causing the driver to lose control and stop the car. This pursuit tactic is frequently used by the police to bring car chases to a safer ending [29].

For a PIT to be well executed, some steps are to be considered: proper training, planning, choice of site and careful timing. It is a stressful situation in which the police officers must make the best choices in order to put the pursued vehicle out of action, at the same time minimizing the impact on the surrounding traffic and assuring that everybody will be safe, including the suspect [30].

The procedure of PIT is not very complicated: the pursuing vehicle pulls alongside the fleeing vehicle from behind, so that the portion of the pursuing car forward of the front wheels is aligned with the portion of the target vehicle behind the back wheels; the pursuer maintains a limited lateral clearance from the target's rear fender, then gently makes contact with the target's side and eventually steers sharply into the target. As soon as the pursued car's rear tires lose traction and start to skid, the pursuer keeps steering in the original direction. Because of the impulsive force resulted from this sudden steering the two vehicles will separate and the target will turn in the opposite direction and will spin out [29].

It is important to mention that still, the PIT maneuver is not applicable in every situation and many factors affect it. It has not been set a standard for the cut-off speed at which the use of PIT maneuver is not permitted anymore, but typical police policy recommends 35 miles per hour (55 kilometers per hour) as being the maximum speed [31]. However, in some cases, the PIT is considered non-deadly force if the police officer does not execute it at speeds greater than 50 mph (80.5 km/h). Nevertheless, in all cases, the location should be chosen carefully and all possible effects on other traffic and pedestrians should be considered with great responsibility [29].

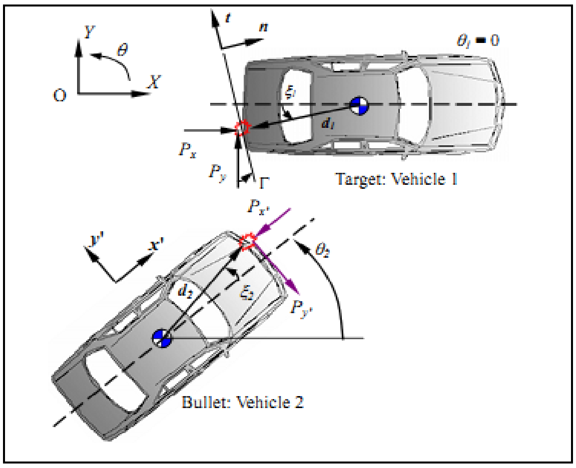

Fig. 2 – The collision scenario [29]. The colored versions could be accessed at http://www.infim.ro/rrp/.

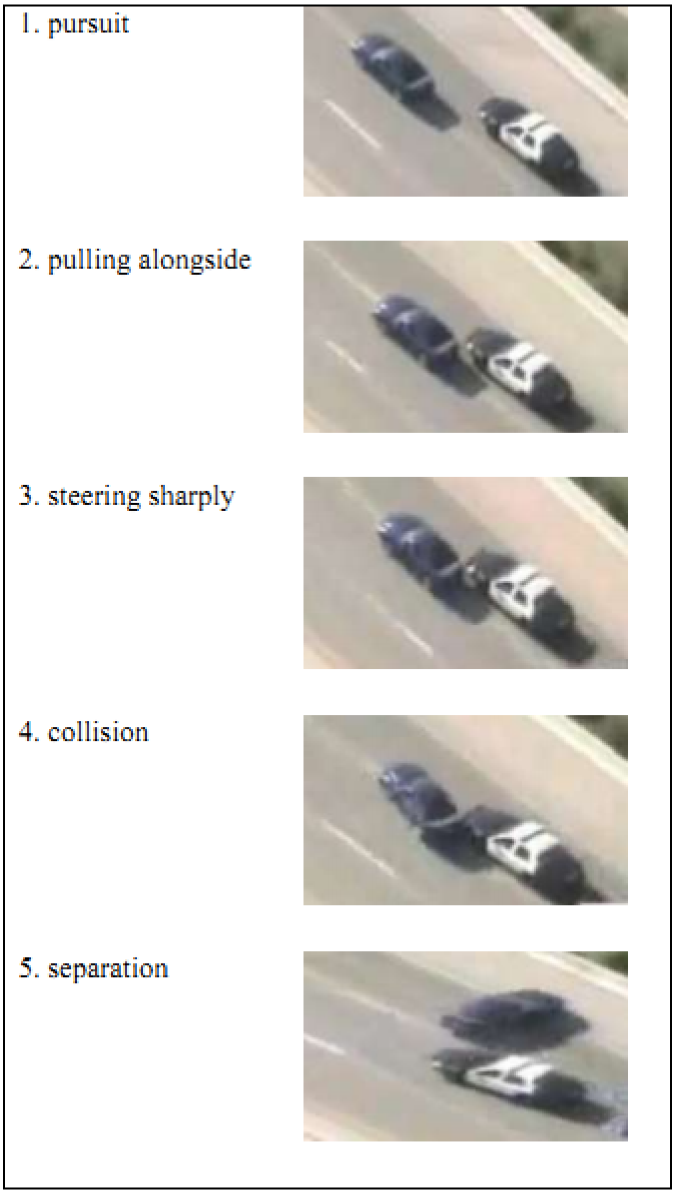

Fig. 3 – The states of PIT maneuver [30, 32]. The colored versions could be accessed at http://www.infim.ro/rrp/.

An earth-fixed coordinate system (XOY) is assumed to align with the road tangential direction, as it is shown in Fig. 2. The orientation angle of the vehicles is denoted as θ. An additional local coordinate system (*n*–*t*) is associated with the impact impulse. The *t*-axis is parallel to an imagined crush plane common to both vehicles, and the *n*-axis is normal to that plane. The choice of the crush plane is case-dependent and should define a nominal deformation surface. The *n–t* coordinate system is related to the XOY coordinate system through the angle Γ [33]. Figure 3 shows the states of PIT maneuver [30, 32].

A total of 12 unknowns need to be solved: post-impact longitudinal and lateral velocities, yaw and roll rates for both bullet and target vehicles (V_{1x}, V_{1y}, Ω_{1z}, Ω_{1x}, $V_{2x'}$, $V_{2y'}$, Ω_{2z}, $\Omega_{2x'}$), as well as the collision-induced impulses acting on the vehicles (P_x, P_y, $P_{x'}$, $P_{y'}$). The eight pre-impact vehicle states (v_{1x}, v_{1y}, ω_{1z}, ω_{1x}, $v_{2x'}$, $v_{2y'}$, ω_{2z}, $\omega_{2x'}$) are assumed to be available. We noted: vehicle longitudinal velocity – v_x, lateral velocity – v_y, yaw rate – ω_z and roll rate – ω_x [29, 33].

Two additional equations are derived from the coefficient of restitution (e) and the coefficient of tangential interaction (μ) [29, 34].

The coefficient of restitution (*e*) is a lumped measure of the energy loss during an impact. It is defined as the negative ratio of the final to initial relative normal velocity components at the impact point. The magnitude of the coefficient of restitution depends on the body/bumper materials, surface geometry, impact velocity, and so on.

$$e = -\frac{V_{2n} - V_{1n}}{v_{2n} - v_{1n}} . \tag{1}$$

The coefficient of tangential interaction (μ) is a lumped measure of the frictional dissipation during the impact, and relates the tangential impulse with the normal impulse [33, 34]:

$$\mu = \frac{P_t}{P_n} = \frac{P_y \cos\Gamma - P_x \sin\Gamma}{P_x \cos\Gamma + P_y \sin\Gamma} . \tag{2}$$

Other two equations project the collision impulses from the bullet vehicle coordinate frame to the target vehicle coordinate frame [29].

$$P_x = -P_{x'} \cos\theta_2 + P_{y'} \sin\theta_2 . \tag{3}$$

$$P_y = -P_{x'} \sin\theta_2 - P_{y'} \cos\theta_2 . \tag{4}$$

4.2. MODELLING THE PIT MANEUVER BY STUDENTS

The group who studied PIT maneuver was formed by four students having different abilities and knowledge, but sharing the same passion: car races. The formulation was atypical. The students represented the maneuver with the help of Sketchup programme, as it is shown in Fig. 4, and then asked their colleagues to answer some questions. They assumed their role as tutors, since their two-week research made them greatly understand the processes.

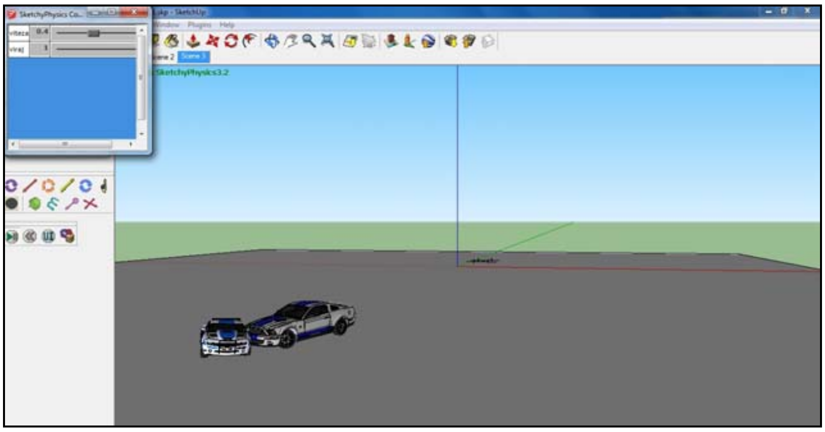

Fig. 4 – The PIT maneuver modeling with Sketchup. The colored versions could be accessed at http://www.infim.ro/rrp/.

The problem proposed by this group was:

"Your friend has called and told you to watch the news. A criminal has escaped and the police are trying to stop him. The action is very dangerous because the fugitive has got a gun. Lieutenant Smith, well-known for his courage, has started following him. When you turn on the TV you see that the lieutenant is a few hundred meters away from the fugitive's car. Then you notice that when the distance between the two cars is 50 m, the policeman's car moves to the parallel lane. After 2.4 seconds the police car is next to the back wheel of the pursued car, and after another 0.5 seconds the collision occurs. As a result, the fugitive's car spins round, changing its moving direction, while the police car goes on at a lower speed. The mass of the criminal's car is 3 tons and of the policeman's is 2.5 tons. At the moment of the impact the criminal's speed is 75 km/h and the policeman's is 80 km/h.

How does the velocity of the vehicle target influence Pit's effectiveness?

How does road adhesion influence Pit's effectiveness?

How does initial lateral clearance influence Pit's effectiveness?

How does coefficient of restitution influence Pit's effectiveness?"

Although the tasks are logical, the solution requires some knowledge above the level students had at the moment of presentation. Even if they knew a lot about kinematics and dynamics of a material point, variation theorems and conservation laws of mechanical momentum, and also about uniform circular motion, the rotational motion of the pursued car could not be explained only with these notions. More than that, a new physics quantity should have been introduced (the moment of inertia) to describe the dynamic of the pursued car.

Yet, these impediments did not diminish the momentousness of the theme and students' interest in fathoming it. This is why the teacher needed 2 of the planned hours to give the theoretical support for understanding the physical shaping of the PIT maneuver.

In the feed-back sheet filled in by the classmates after each presentation, the students should specify three characteristics of the material. The answers of the 26 colleagues of this group were: interesting (24), original (15), outstanding (11), useful (10), exciting (8), difficult (8) and unclear (2).

It is noticed that when the theme to be studied is according with the topics of interest for students and it approaches real life situations, the motivation for study dims its difficulty. This can be an argument for introducing in textbooks problems with a divergent character which challenge the student to fathom and extent the subject.

5. CONCLUSIONS

Instructing students according to the current textbooks can activate the creative function to a certain extent, but this can be stimulated by solving new problems and applications, in which the divergent tasks with multiple solutions are predominant. Students need to be guided to solve the proposed problems through different methods, to use their methods and build their own strategies to investigate reality, and to elaborate new products based on the subject.

An important role in developing the students' creative capacities is played by the tasks of creating problems based on unproblematized materials, by creating problem-questions and solving them through associations of ideas, analyses, relationships, successive tries, inductions, individual learning and sketches [13].

The role of the problem is to serve as a stimulus for learning. The difficulty will not simply disappear by just ensuring that well designed problems do not undermine intrinsic motivation. Each problem is delivered in a context and that context also needs to be planned to support the motivating nature of the problems. A clear case in point is that of a student's workload and its influence on the capacity to control his or her learning. It is well known that an excessive workload is a demotivating force [25].

Students' interest in scientific contents is based on their perceptions and expectations connected with the real life. That is why the teacher's job is to offer his students challenging learning situations, at first ignoring the level of their cognitive acquisitions. Later, after students' researches and teacher's explanations, progress will be noticed, not only quantitatively, but more important, qualitatively, since students will definitely enlarge their knowledge and improve their skills. It is not to be neglected either the stimulation of students' creativity during the process of solving the problems, the modern methods making the most of the students' creative potential.

A teacher's role should be to stimulate curiosity, to motivate and to build self-confidence regarding Physics. Further on, teachers can make a large difference to their students' enthusiasm for a subject, as well as directly influence their students' achievements [35].

Nowadays the teacher cannot only be an information provider. As we have presented in this paper, students' information channels are diverse, therefore they can have access to very complex information. The teacher has to make this information accessible, to integrate it in the already formed notional system, at the same time eliminating the cognitive ballast, and most of all, to teach his students how to use the information acquired in non-formal and informal context in order to solve some real life problems.

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