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STRIKE A BALANCE

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The subject of forces and Newton's laws are discussed in detail in middle school, when students first encounter vectors. Building equations and expressing the unknown variable are also subjects of middle school mathematics. Why do students face such difficulties solving physics problems? We are looking for methods and ideas how to help them by teaching both subjects collaboratively.

INTERESTS OF OUR INQUIRY

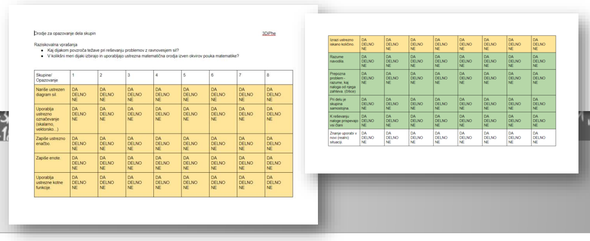
- What are the main obstacles for our students solving problems in regard to balance of forces?
- To what extent do our students use proper mathematical tools outside math lessons?
- How many students are able to apply knowledge of Newton's first law and resolving forces to components in an authentic situation?

PLAN OF INQUIRY (PI)

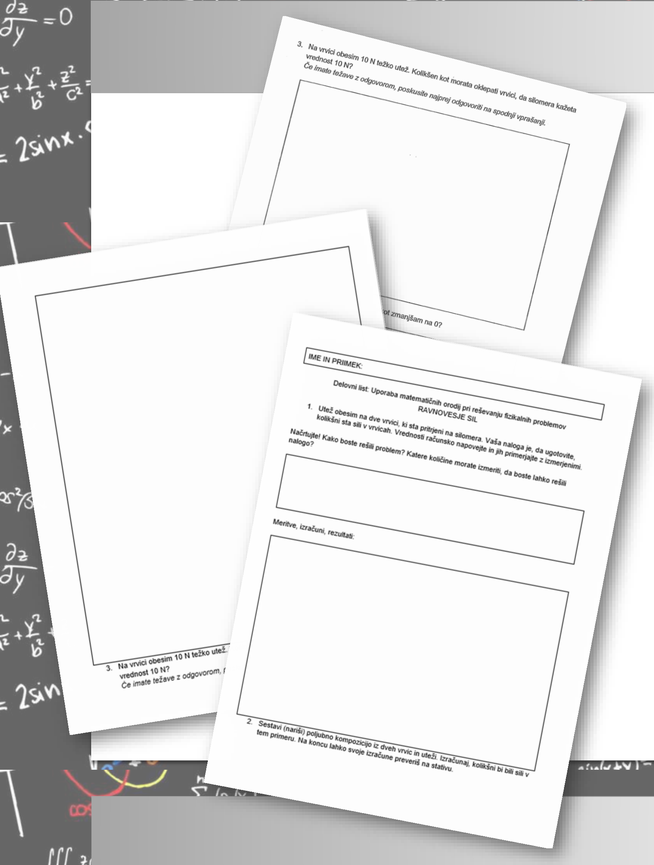
PLANNING AND PREPARATION – focus on collaborative learning and cross-curricular teaching
- Coordination of math and physics lessons concerning adding and resolving forces to components, the balance of forces and trigonometric functions in the right triangle both at math and physics classes.
- Preparation of worksheets for students and the tool for recording the observation made during the lesson and the agreement about the manner of collecting data.
- Video conference with mentors of PI
- Forming heterogeneous groups of students and preparation of the classroom.

IN THE CLASSROOM – focus on collaborative learning
- The students explore the balance of forces throughout the situations described on the worksheet. After the class is over, we collect the worksheets and check them.
- Notes about the students' work (independence, the correct use of trigonometric functions in the right triangle, drawing diagrams of forces with correct labels) are recorded in the prepared form/tool.

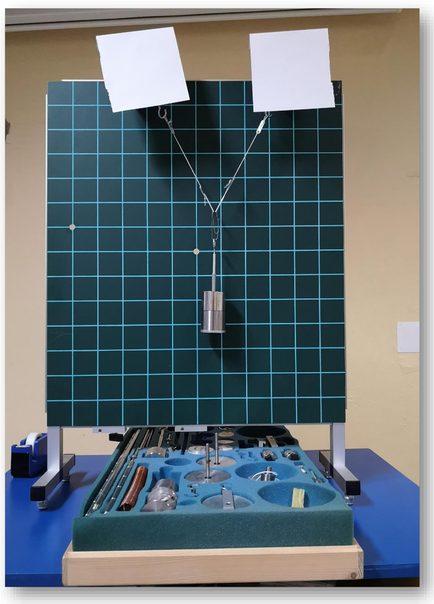
EVALUATION:
- Discussion about the lesson, sharing impressions, analysis of the teachers' notes (recorded data)
- Overview and analysis of students' worksheets.
- Planning activities to improve the current state.



STUDENTS' ACTIVITY



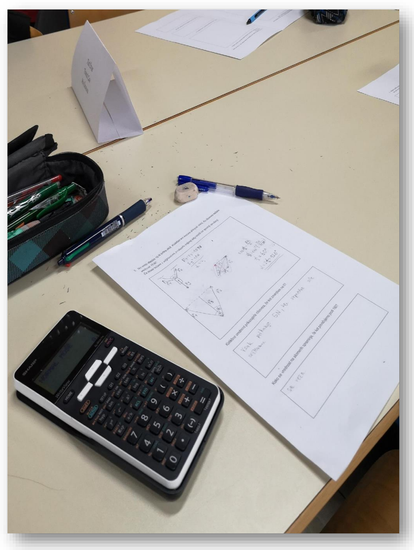
1. The students observe the situation – the weight hanging on two strings attached to two force meters. The goal is to determine the size of the forces in strings. After the calculation of the forces, they compare their value with the measured values.
2. The students assemble their own composition with weights, strings and force meters and repeat the task above.
3. Students have to measure the angle between the two strings so that the forces in the strings are equal to the force of gravity on the weight.
4. The transfer of acquired knowledge is tested by an authentic task: how to pull a car out of a ditch using only a rope and a tree on the other side of the road.



About the students:
- 25 students - boys, Electrical engineering program; 2nd grade
- First year of physics on high school level
- Number of math lessons this year 60/130; number of physics lessons this year 100/170

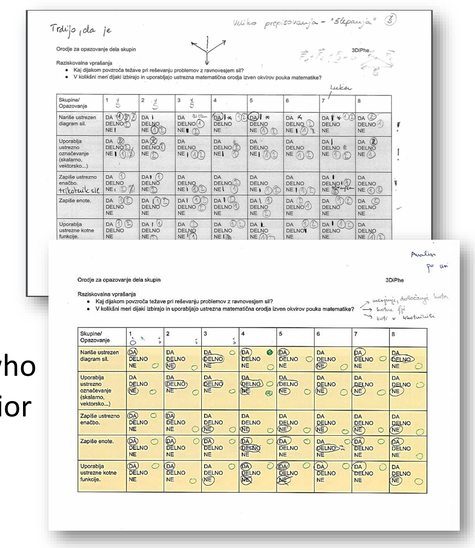
About the organization of the inquiry:
- The groups of students were determined in advance – heterogeneous groups.
- The students perform a guided study – the questions were set up in advance, all the groups were solving the same task at a time.

COLLECTED DATA

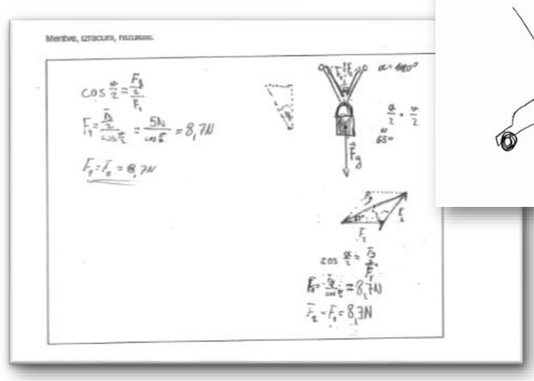


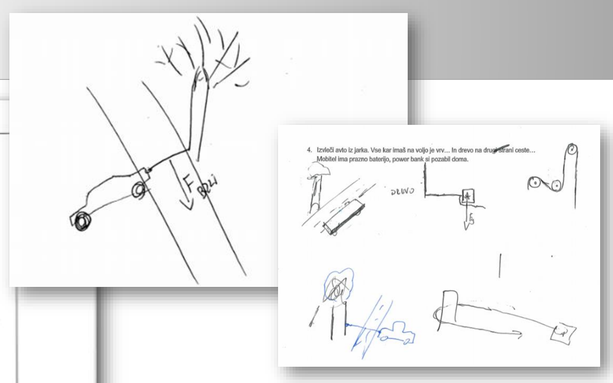
Heterogeneous groups do not encourage group work. Students who consider their knowledge and skill inferior did not contribute to the common goal and were entirely dependent of those considered superior.

The activity was too excessive concerning the abilities and motivation of the students. For the same reason the tracking of the results was difficult, almost impossible.



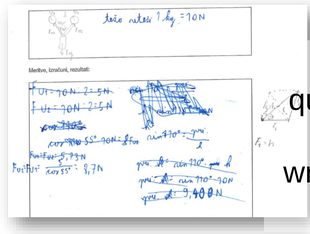
The students do not use the correct labelling of the forces, they do not draw the relevant diagrams of forces, and consequently they do not use the diagrams to solve the task.



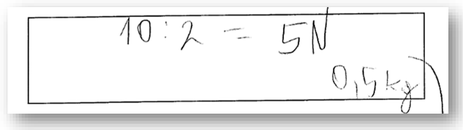


Only one student solved the authentical task.

There were difficulties with the students' independence, especially with the first task. The students needed quite some guidance and motivation to draw the correct diagram of forces. Some problems occurred with identifying the triangle that would enable the use of trigonometric functions. Once the right triangle was recognized, the majority of groups used the correct trigonometric function and consequently expressed the required valuable.



The students were quickly satisfied with simplified or even wrong solution of the task.



Students do not draw proper force diagrams. Nevertheless, this being one of the compulsory learning goals of secondary education, students did not use force diagrams while solving a statics problem. More focus has to be applied on that in the future, before attempting independent student inquiry on this subject.
Students were successful in using correct trigonometric function and consequently expressed the required valuable.
Heterogeneous groups do not encourage group work, quite the opposite. Groups will be formed homogenicaly in the future and tasks will be adapted to several levels of skill and knowledge. We will divide our tasks concerning our joined PI so that one of us will be recording data for PI and the other coordinating student's work.