Modern methods of introducing basic Physics concepts: The coordinates and the GPS

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1 Motivation

In order to transform the very young student in an active person which, guided by teachers, discovers and scrutinizes new knowledge territories, there are new teaching strategies in agreement with student's learning manners:

• the lesson should embrace questions and activities that involve the student;

• as part of the lesson, one uses a combination of activities which tackle different learning manners that the student prefers: visual, auditory, practical;

• the lesson involves an active participation of the student in the learning process, through accomplishing experiments, simulations and problems by means of a computer, even when the students start to study/discover Physics.

In education the increase in efficiency is determined by the development of permanent learning competences and of students' and teachers' creative skills.

According to Ausubel, "the most important single factor influencing learning is what the learner already knows".

Thus, meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts they already possess. When meaningful learning occurs, it produces a series of changes within our entire cognitive structure, modifying existing concepts and forming new linkages between concepts. This is why meaningful learning is lasting and powerful whereas rote learning is easily forgotten and not easily applied in new learning or problem solving situations which the present science curricula so advocate.

So, taking into account that the 6-graders are at the very beginning of their Physics study, these "anchors" should be secured into the foundations they got from the study of other subjects. The scientific content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting and relevant to the student's lives. The program of science study should connect to other school subjects. The curriculum must put more emphasis on connecting science to other subjects, such mathematics, chemistry, biology, geography, and less emphasis on treating science as a subject isolated from other school subjects.

Use of computers and ICT software tools in classrooms and laboratories provide much more effective and efficient environments in teaching and learning, making physics a science easier to understand. The advantages of using simulation software in conjunction with classroom teaching are well known. It is generally accepted that the use of interactive teaching tools, which provide instant feedback to the student's inputs, improve and accelerate the learning process. The use of simulations and ICT tools in secondary education is not a new concept.
In order to lead the young aspiring scientist's mind toward complex experiments, solid fundaments must be laid down from the very beginning.

2 Target:

Student from grades 6 and 7

3 Objectives

The main objectives are:

- supporting students hands-on learning of science;
- delivering hands-on activity resources to educators;
- learning more about Physics in an unconventional way;
- pointing out anchor-knowledge necessary in teaching new concepts, and training the students in the area of conceptual and operational structures constructions;
- integrating the achieved knowledge and intellectual strategies into a derived general scientific frame;
- uncovering areas of special need that may be difficult to identify without special assessment;
- inspiring the next generation of engineers and scientists;
- integration of the achieved knowledge and intellectual strategies into a derived general scientific frame.

Students will:

- practice using maps;
- understand the underlying principle responsible for the working of the GPS;
- use a GPS unit and understand latitude and longitude coordinates;
- understand the importance of avoiding measurements errors;
- understand the importance of adopting adequate units;
- use mathematical calculations to solve practical problems;
- be able to use a GPS unit to conduct scientific inquiry and demonstrate that changes in motion can be measured and graphically represented;
- be able to distinguish between scalar and vector quantities, between displacement and distance, between velocity and speed.

4 Activities

The structure of the lessons will consist of three modules, each representing an important activity, which the teacher can assemble at its own will or skip altogether. Students getting acquainted with the underlying principle responsible for the working of the GPS.

1. 2D and 3D student-made animations will be used. The animations were developed by students from the Tudor Vianu National High School of Computer Science under my guidance and supervision. Some basic concepts regarding measurement and orientation, such us maps, units, measurement errors and coordinates, will be introduced (see/GPS_ http://portal.opendiscoveryspace.eu/beta/educational-objects/70475).

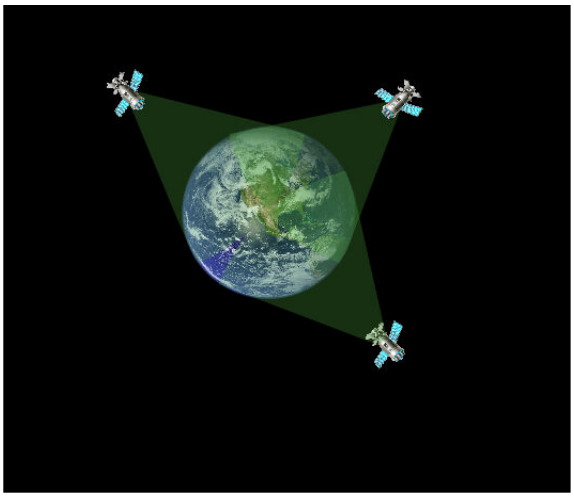

Figure 1. Screenshot from the GPS Educational Software

2. Educational game software: reading maps and making use of adequate units, the students will find on the maps certain given locations, acting similar to the working of the GPS. They will have to solve riddles, use mathematical hints, transformations of units and changes of coordinates, which will all point toward those locations (see/use the GPS_PLAY educational software http://portal.opendiscoveryspace.eu/beta/educational-objects/70475 and the attached work sheet).

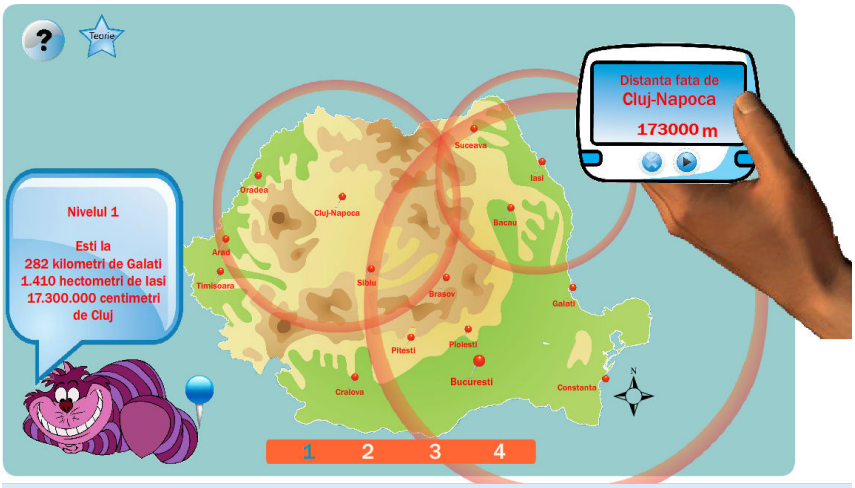

Figure 2. Screenshots from the Educational Software game

3. A hands-on activity that will involve arbitrary measuring units in order to find a number of "treasures". The class will be split into two teams, and the students will be presented with their tasks. They will have to use the inner working of the GPS and to do simple calculations (Pythagoras' Theorem, units' transformations) and the teams will compete to discover the treasures as fast as possible in order to win the game. Each team will receive a working sheet with specific details.

5 Assessment

The students will be assessed on the basis of the working sheets given at activity number 2 and of the educational software for the same activity. Each discovered place will be one mark. The students will receive grades proportional to the number of places/marks discovered with the help of the game. Supplementary, all the students from the winning team will be rewarded with maximum grades.

6 Advantages

The traditional teaching methodology used in secondary education is based mainly on oral speech and use of the blackboard. But it is important to generate understanding using situated examples, visualizations, and dialogues. By using situated examples, the teacher should make the students able to understand the software problem. The principles of the software are then explained through visualizations. Finally, the teacher gives the right sequence of software instructions showing the main implementation steps of the problem solving process.

On the other hand the students can use software principles to construct solutions to the problem through involvement in realistic task-based activities. The goal is for the students to construct their knowledge and to work at their own pace from their prerequisites. The teacher works as a mentor and guide of learning rather than as a transmitter of knowledge.
Another advantage offered by this type of lessons is that it includes stimulation of the creativity and of the competition spirit, unconventional tests allowing for an optimal feedback, user-friendly working environments, individual and/or team work visual support, which all offer rapid understanding of even the most subtle and complex scientific themes. By means of an educational game, this lesson allows for a more intense involvement of each student into the learning process: the student will learn by playing in a rigorous mathematical way, because mathematics, creativity, logic, and originality are all needed to improve technology.

Using a cross-curricular approach, the students can get an encompassing view not only over Physics, but also over different another fields (mathematics, geography, computer science). The students will get to know the practical side of Physics and the way information from Physics can be used in other areas. They will study some basic and more complex directional skills so they can navigate nature and the greater biosphere.

Through these lessons, students can access information in real time using GSP software, and can even get in contact with other students who work in the same environment. In this way they will develop working skills both individually and in team, as well as communication abilities and a competitive spirit.
The assessment is an unconventional one, allowing for an optimal feedback.
The teacher who can choose certain lesson stages which are in accordance with topics from the school curriculum, but he/she can also create sequences based on the feedback received from a certain group of students, or on the strategies that he/she uses.

3 Conclusion

The teaching-learning-assessing process needs a student-teacher team, as well as needed to be active. Each didactic activity should be authentic, specific and oriented towards applications that will attract the student.

I strongly believe that the usage of modern technologies, such as GPS, and of educational software is a must for the educational process, an addition to the classical methods, appealing to the individual character of each student.

4 References

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Work Sheet

1. **In this question you will be given some information about how far you are from three cities and your goal is to find your location. This will model how GPS SATELLITES LOCATE A POSITION.**

Use the map of Romania handout and the clues below to locate the city that fits the criteria in the clues (the teacher can choose any map and locations).

- You are located 2154 Km from Bucharest.

a. If you only knew how far you were from Bucharest, at which points on the map could you be located? Label these points on the map.

- You are also located 1879 Km from Iasi.

b. If you only knew how far you were from Bucharest and Iasi, at which points on the map could you be located? Label these points on the map.

- You are also located 2464 Km from Brasov.

c. Write down the name of the city you have located.
d. The GPS uses information from four satellites. What extra information does using this many satellites provide?

2. **We know that a GPS satellite orbits 20 200 Km above the surface of Earth.**

Suppose a GPS satellite is over Halifax, Nova Scotia. We will calculate the time for the signal sent from the satellite to a GPS receiver in Ottawa, Ontario.

- To calculate this, measure the distance from Halifax to Ottawa: _____cm.
- Use the scale and record the number of kilometers from Halifax to Ottawa: _____Km.

- Using Pythagoras' Theorem calculate the distance the signal travels.

- Knowing the speed of the signal, 3.00 x 10^5 Km/s, and the distance the signal travels, calculate the transit time for the signal to reach the receiver from the satellite.