**A CASE STUDY ON**

# Introduction to Nanotechnology – Nanoscale

**in 2nd Gymnasium of Heraklion, Greece**

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## INTRODUCTION / BACKGROUND

Those Virtual Lab implementations took place in Second Gymnasium of Hereklion Crete, Greece during November 2013. The work was conducted in four classes (8th grade) with 90 students in total. Students had the opportunity to explore and understand the metric system, nanoscale, properties of nanoscale particles and what nanotechnology deals with.

**KEYWORDS:** Nanotechnology, nanotechnology applications, nanoscale, biomimicry

**TARGET GROUP:** 8th grade students

## THE EDUCATIONAL SETTING

The Second Gymnasium of Heraklion is a school with a very good reputation in the city of Heraklion, Crete. According to data gathered from the school, the average score of these four classes that took part in the VL implementation is 16.2/20 (physics and chemistry).

The school was very active during the nano poster competition since eight groups of students participated in the competition. The winning poster for Greece came from this school. Four students (older than those participating in these implementations) along with the headmaster took part in the nanocamp in July, 2013.

The lessons were carried out by two physics teachers, Ms Paraskevi Ktistaki (group A) and Ms Theodora Katsiouli (group B) with the assistance of Yorgis Androulakis from FORTH. Both teachers had over 10 year experience in teaching physics. Ms Ktistaki reported much experience in using on-line resources for teaching and learning while Ms Katsiouli reported average experience.

### PURPOSE

The aim of "Nanoscale and Nanotechnology" lesson was to introduce nanotechnology and nanoscale to the students by using the material provided in the Virtual Lab. By the end of this activity, students should have develop the ability to convert ordinary measurement scales into nano, visualize the nano scale, give examples of nanoscale objects and differentiate nanotech applications from the applications of conventional technology.

### OBJECTIVES

The lessons' objectives were:

- ✓ To increase awareness about nanotechnology through nanotechnology applications
  - ✓ To comprehend nanoscale
  - ✓ To enhance the ability to convert units into nanometres
  - ✓ To comprehend how the surface/volume ratio affects the physical properties
  - ✓ To comprehend that nanotechnology imitate natures technology

**LEARNING RESULTS**

The proposed activities should allow students to:

- ✓ develop the ability to convert ordinary measurement scales into nano
- ✓ visualize the nano scale
- ✓ give examples of nanoscale objects
- ✓ differentiate nanotech applications from the applications of conventional technology
- ✓ understand why the material gain new properties when the particle size decreases to nano

**BEFORE THE LESSON**

The students were provided in advance with the "Student's Guidelines" booklet, available in the Documents section of Virtual Lab.

Students should already know the following terms that exists in the reading text:

- ✓ SI Units
- ✓ Ability to convert units
- ✓ Ability to calculate volumes and area of cubes and cuboids

The room was prepared to watch the PowerPoint presentation and the related videos / interactive application. Four sets of prebuild cubes and cuboids were arranged in the classroom. Nanorulers were available to all students.

**CLASSROOM MANAGEMENT & SEQUENCE OF EVENTS**

There were some deviations from the original lesson plan:

- The video "Powers of Ten" was not used due to time constraints. Emphasis was given to "Scale of the Universe II" interactive application.
- A PowerPoint presentation titled "Introduction to nanotechnology" was used.
- Two short videos showing nanotechnology applications (nano-coating), future materials (buckypaper) were also used

| | |
|---|---|
| Introduction to Nanotechnology<br><br>13 minutes | A PowerPoint presentation introducing Nanoscience, nanotechnology applications, nanoscale and biomimicry. |
| Nanotechnology Applications<br><br>7 minutes | Two videos regarding today nanotech applications<br>1. Nano-coating http://www.dailymotion.com/video/x13jfyp_amazing-technology-with-nano-coating-2013_tech )<br>2. Future applications of buckypaper http://www.youtube.com/watch?v=nRMiQRiK5GY |
| The Scale of the Universe<br><br>15 minutes | Interactive application showing the scale of various objects. Focused in micro and nanoscale students were asked to identify objects and their sizes to compare sizes of different objects, to identify the smallest object visible to an optic microscope as well as to an electron microscope and also to point the largest /smallest scales. |
| Converting to nanoscale<br><br>3 minutes | Students were asked, by using their nanorulers, to convert in nano the sizes of some objects like books, pencils, rubbers etc. |
| Surface to volume ratio<br><br>7 minutes | Students were asked to compare the total surface areas that were pre-built of sugar cubes structures (one cube and 3 cuboids) all of the same volume and calculate the surface to volume ratio in each case. |

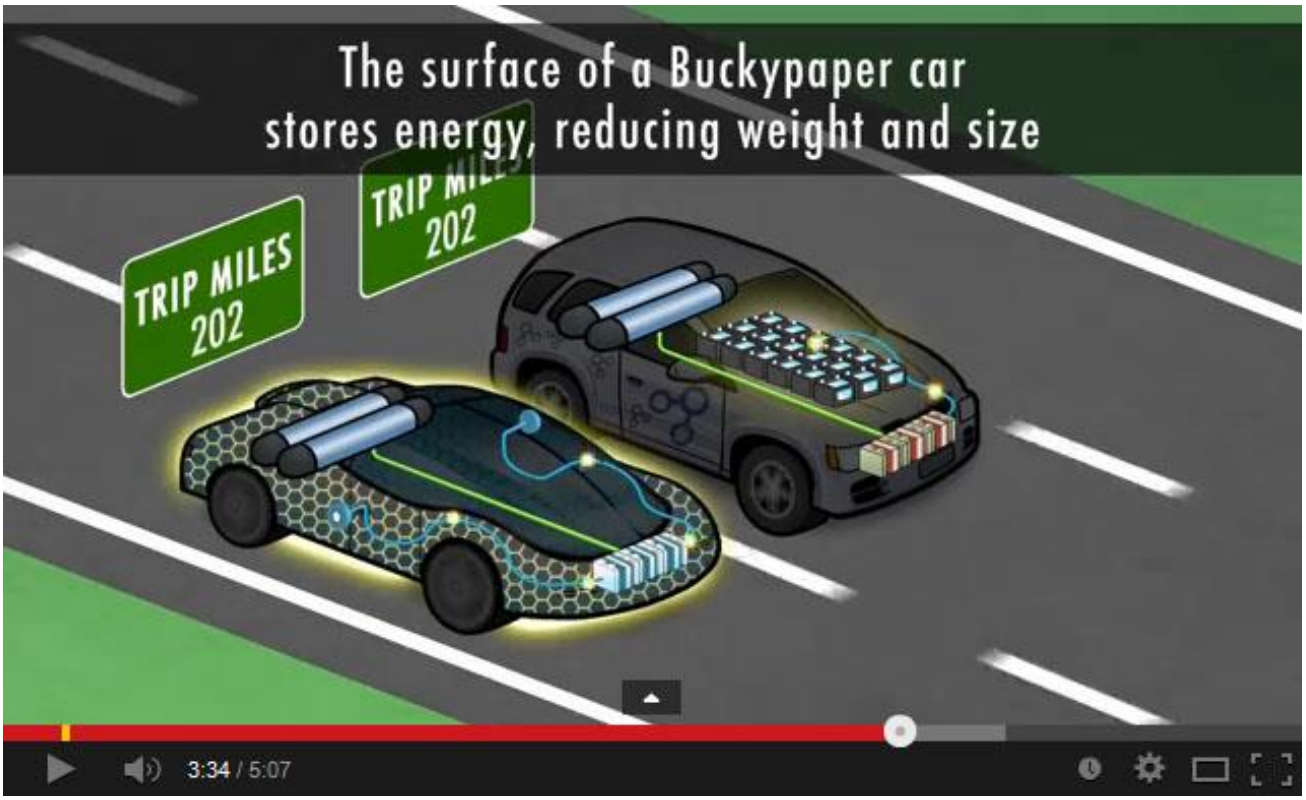



*Figure: Screenshot from the short video "2. Future applications of buckypaper"*

The duration of the lessons was 45 minutes. At the end, all students and their teachers filled in questionnaires and assessment grids. The questionnaires aimed at evaluating and collecting information and suggestions on the content, usability and pedagogical effectiveness of the NTSE Project teaching materials (video, interactive animation, teacher guidelines, student guidelines).

**IMPACT ON STUDENTS**

Below are the results of the analysis of the students' questionnaires.

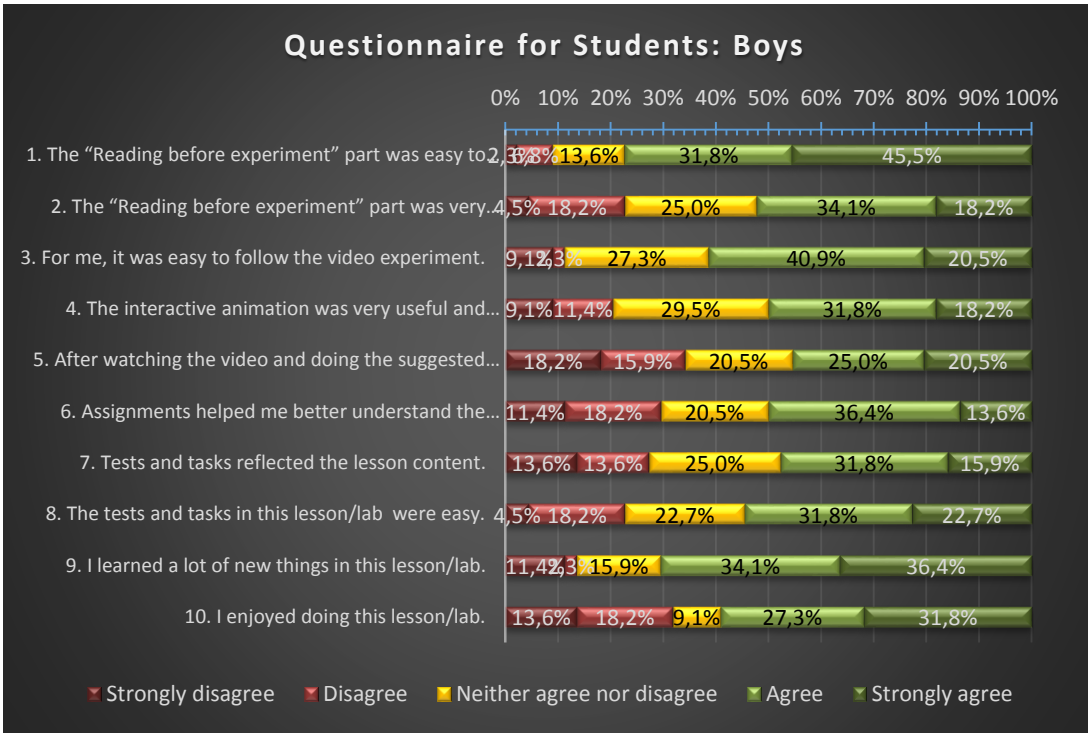



*Figure 1: Questionnaire for students – Boys' responses (n=44)*

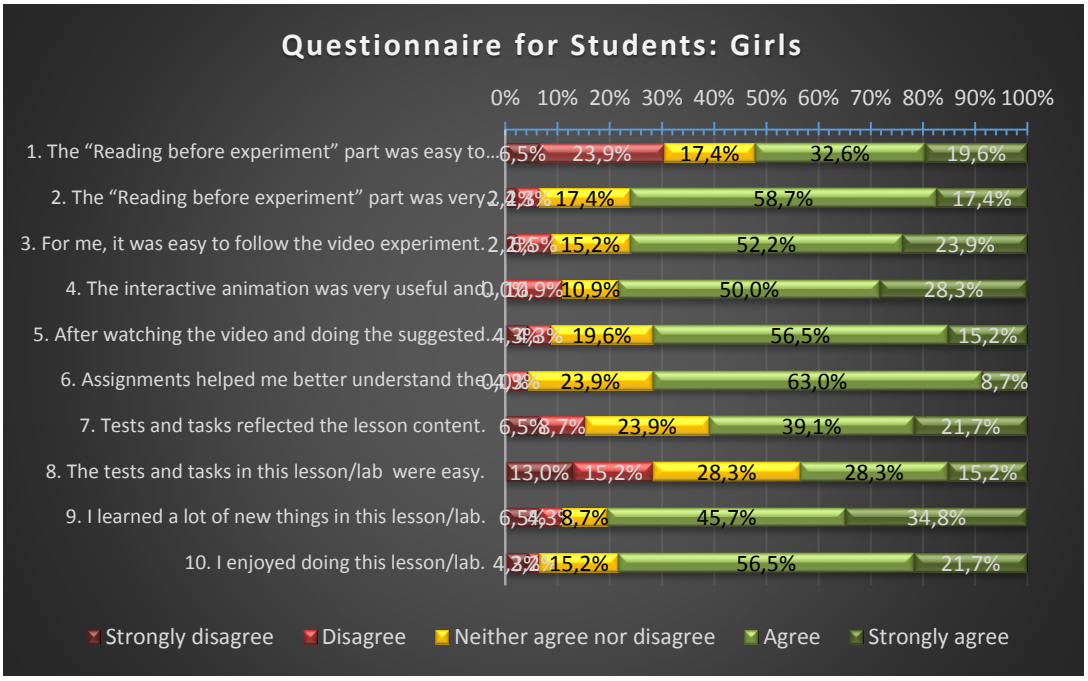



Figure 2*: Questionnaire for students – Girls' responses (n=46)*

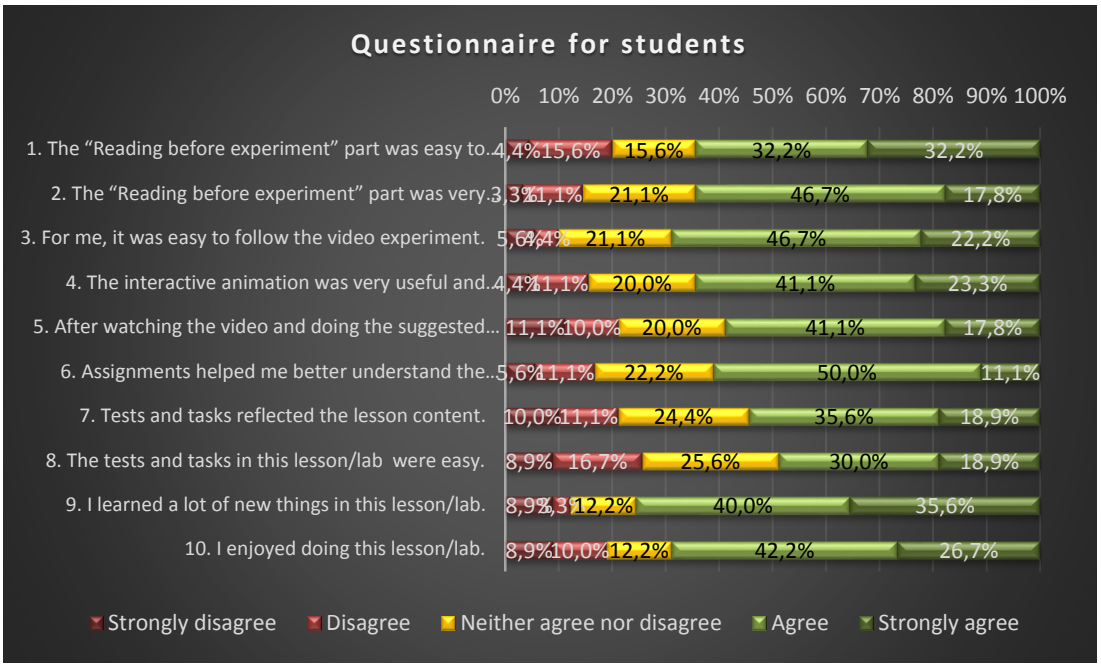



*Figure 3: Questionnaire for students – Responses from all students (n=90).*

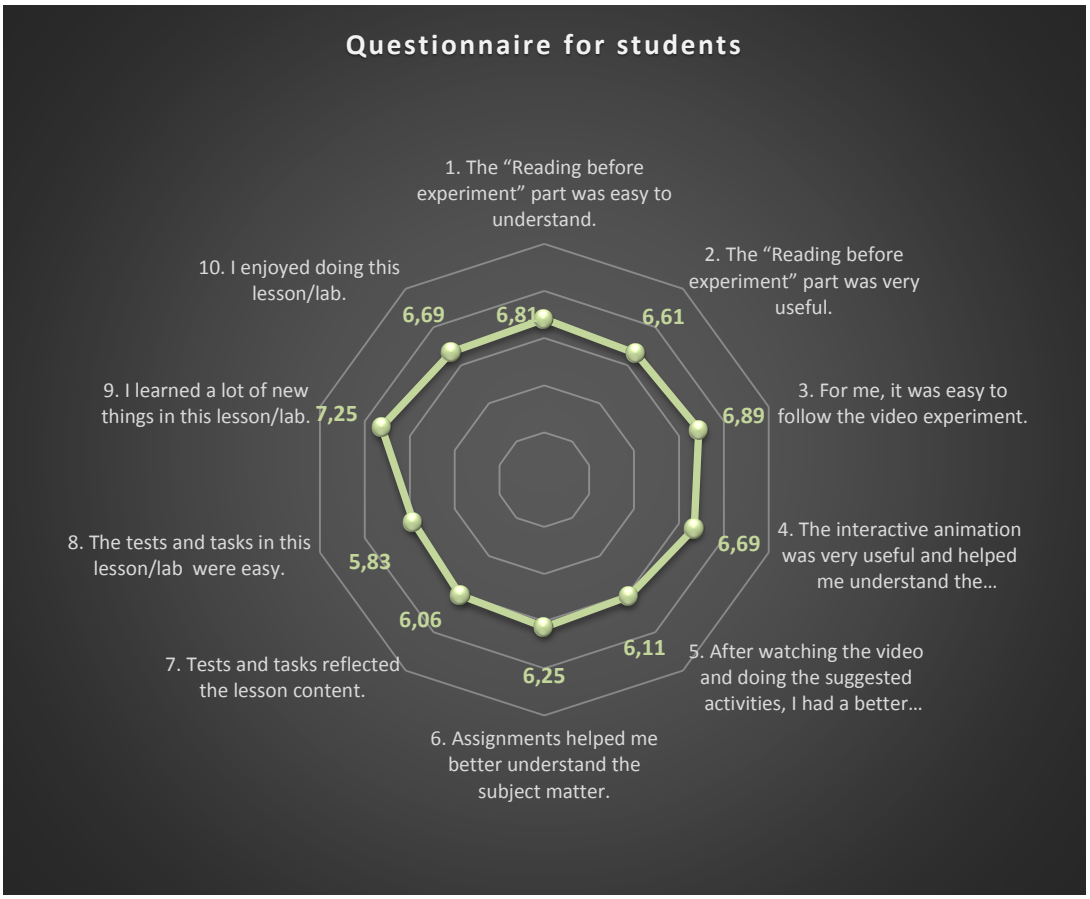



*Figure 4: Questionnaire for students – Responses from all students (n=90), mean numbers*

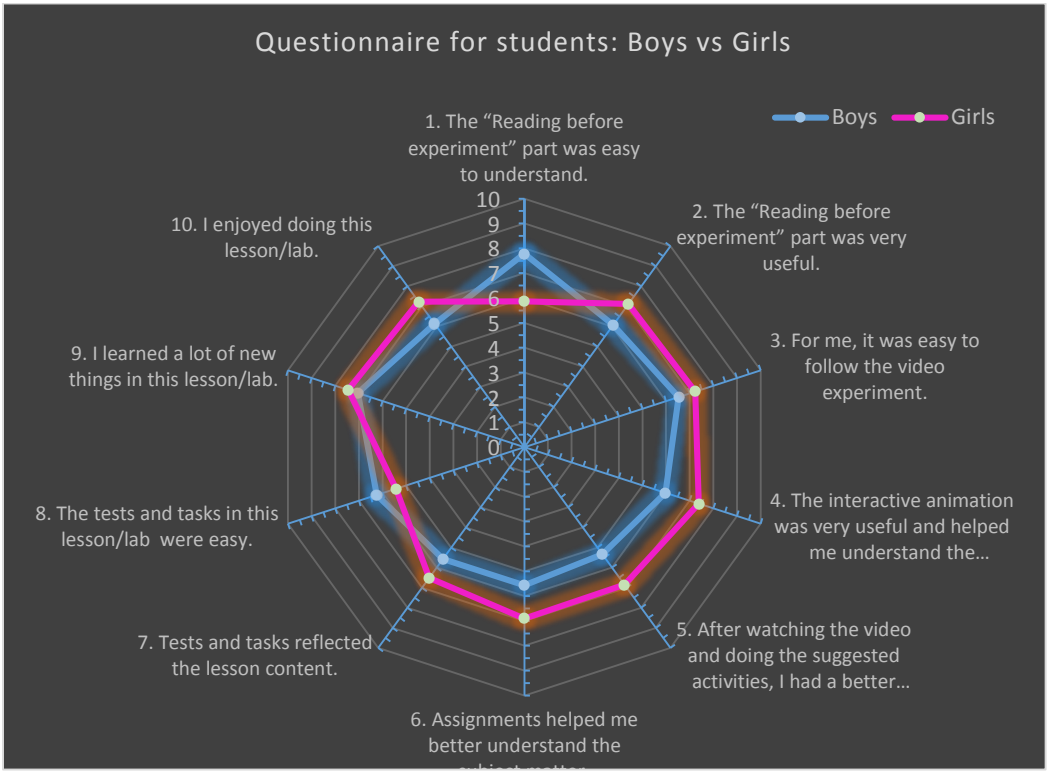



*Figure 5: Questionnaire for students – Responses from all students (n=90), boys vs girls.*

Students enjoyed the lesson and learned many new things. But 4:10 of them had difficulties with the tests. In general, they seem to have a good grasp of the subject.

Girls scored significantly higher in most statements even if they had more difficulty with the "Reading before the experiment" part than the boys.

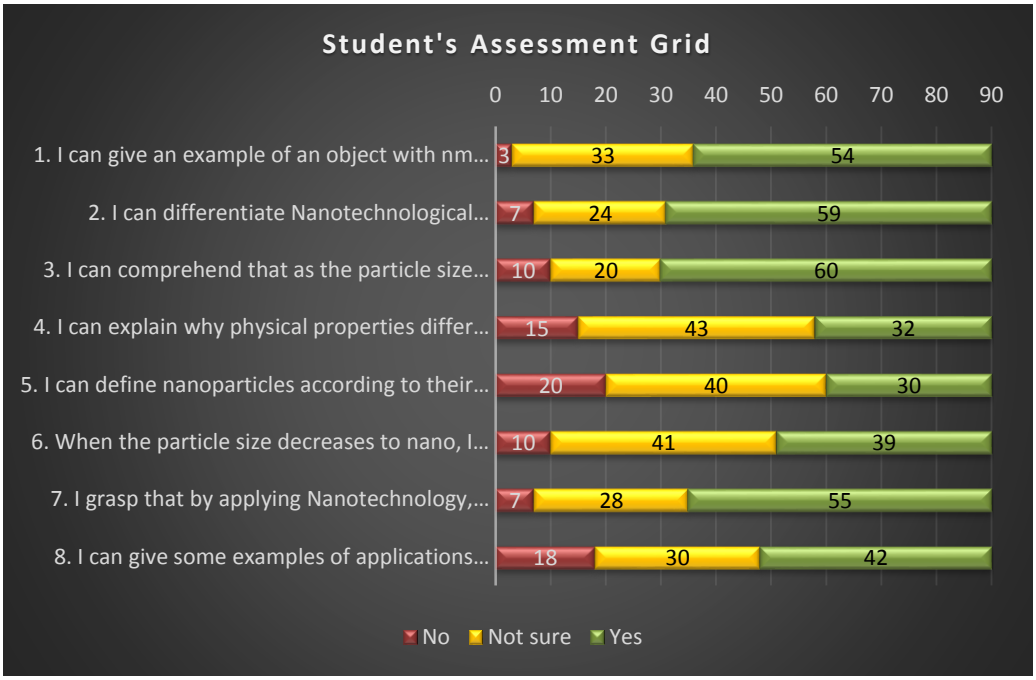



*Figure 6: Assessment grid – Responses from all students (n=90)*

Difficulties in defining nanoparticles and explaining the relation between physical properties to size/volume ratio were observed.

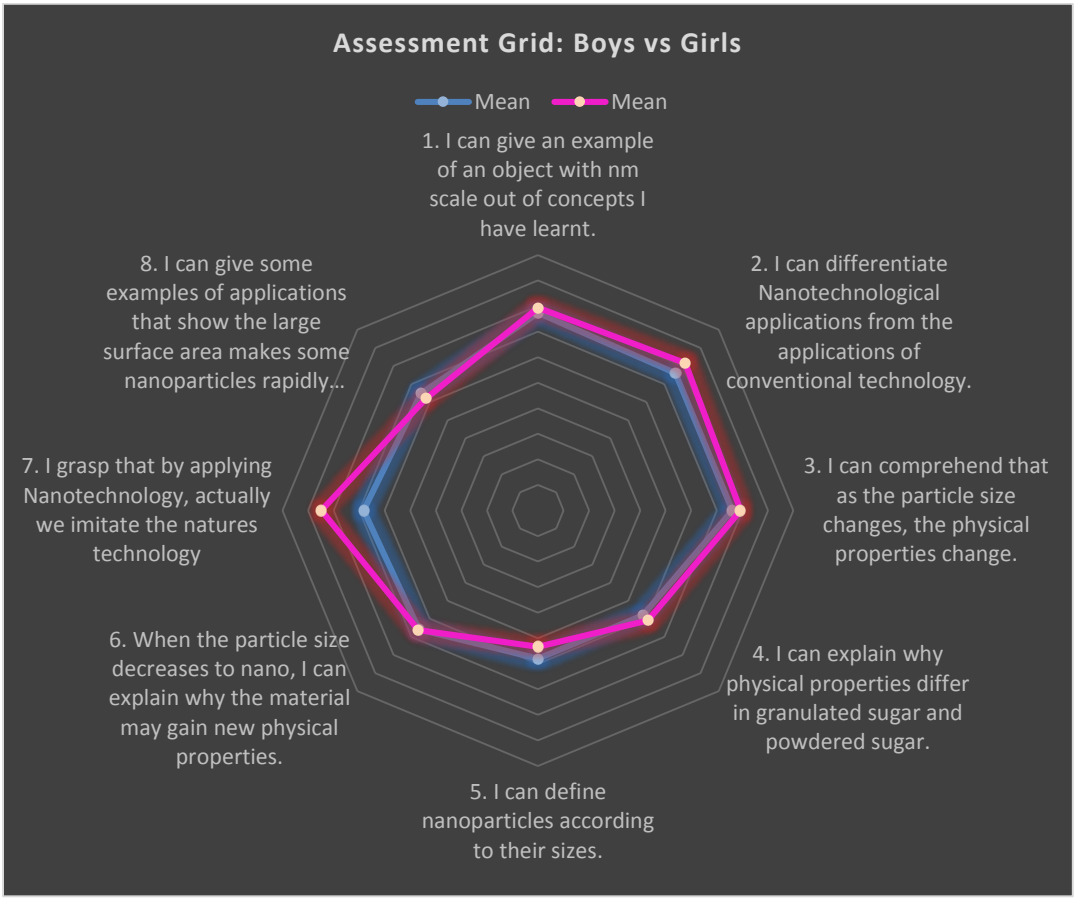



*Figure 7: Assessment grid – Responses from all students (n=90), boys vs girls.*

No significant differences in comprehension of nanoscale concepts were noted except that girls comprehended the concept of biomimicry better.

**TEACHERS REFLECTIONS**

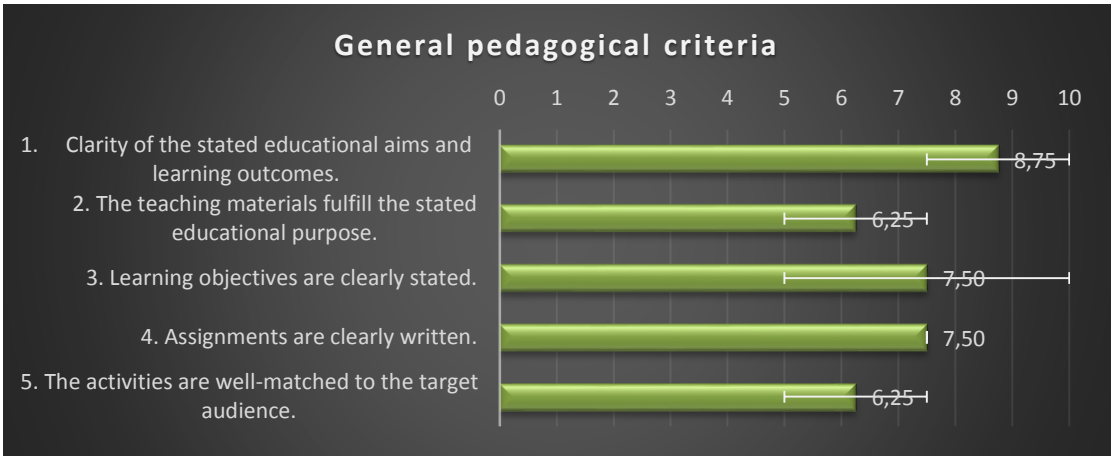
The following analysis is based on the teachers' views and suggestions regarding the content, usability and pedagogical effectiveness of the Virtual Lab.

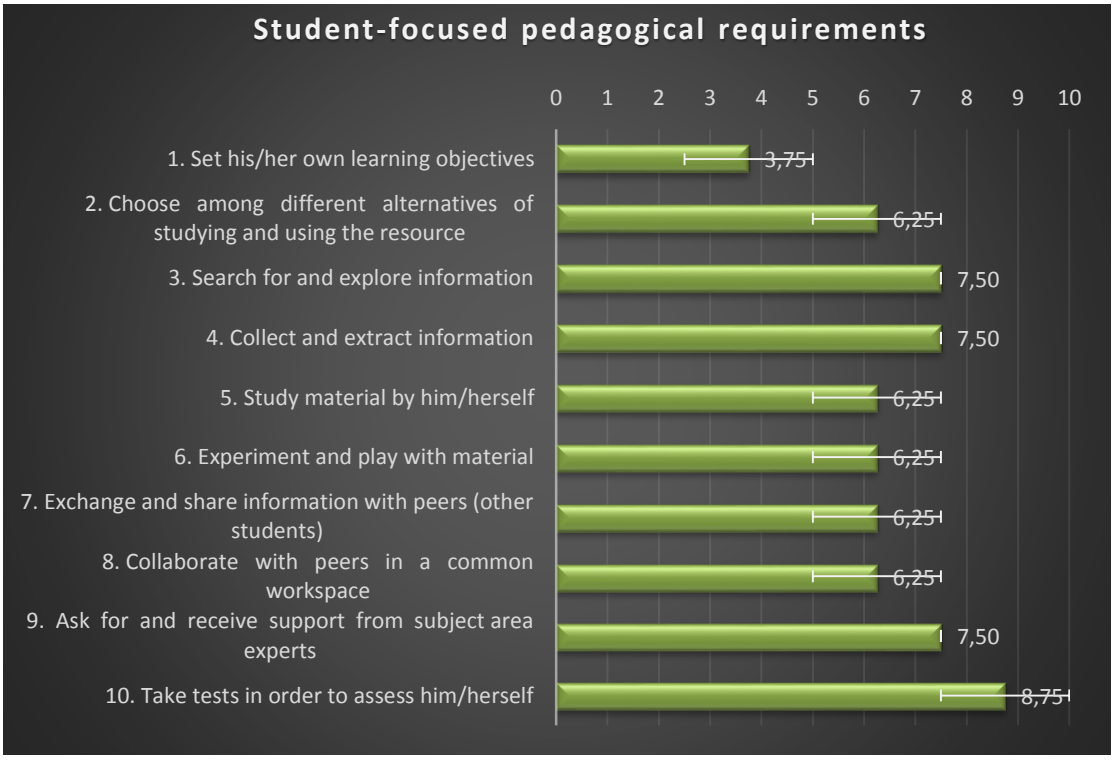
Following the VL implementations, both teachers asked to fill in an evaluation questionnaire.

**Pedagogical approach**

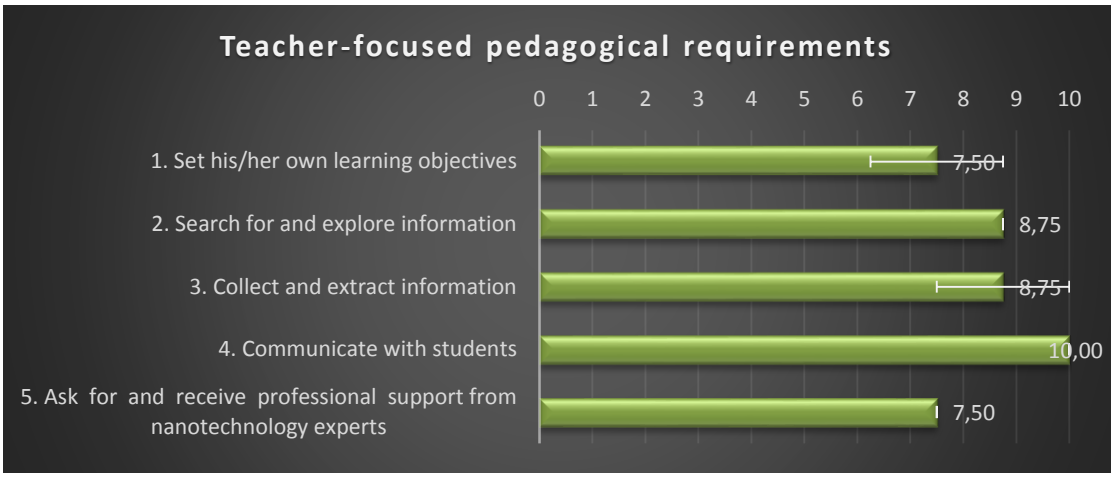
The pedagogical effectiveness of the Virtual Lab educational materials was evaluated with three sets of questions regarding general pedagogical criteria, student-focus pedagogical requirements and teacher-focus pedagogical requirements.

The charts below shows their responses:



It is worth mentioning here the relatively low score of "Set his/her own learning objectives". This was expected in a way since the VL experiments are more towards the structured / guider inquiry-based learning rather than open inquiry-based learning.

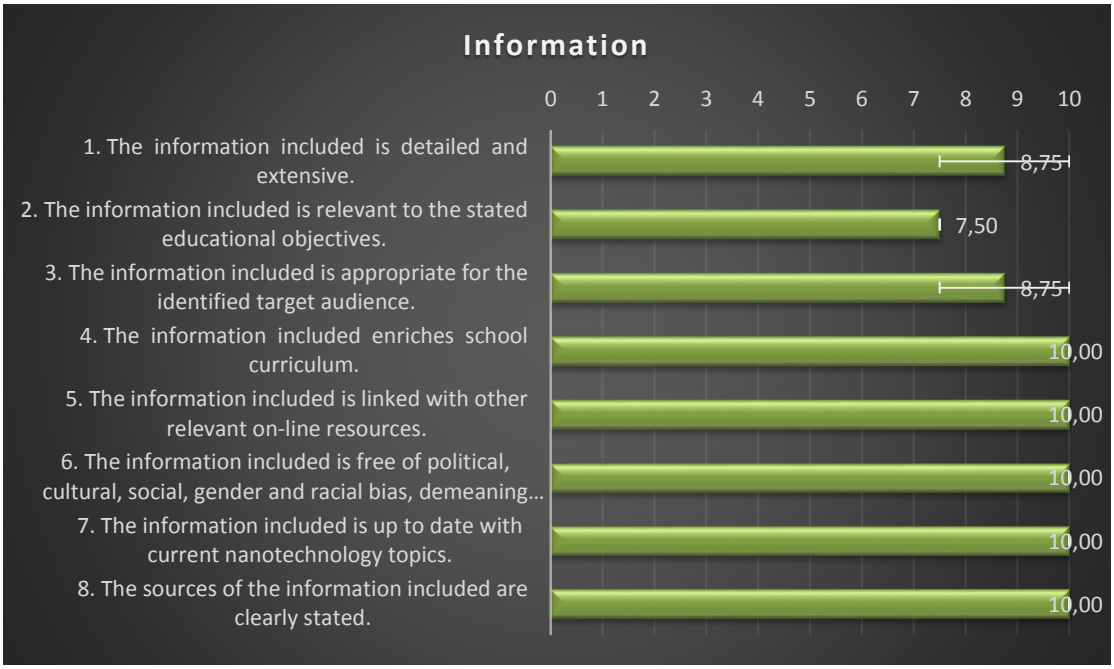


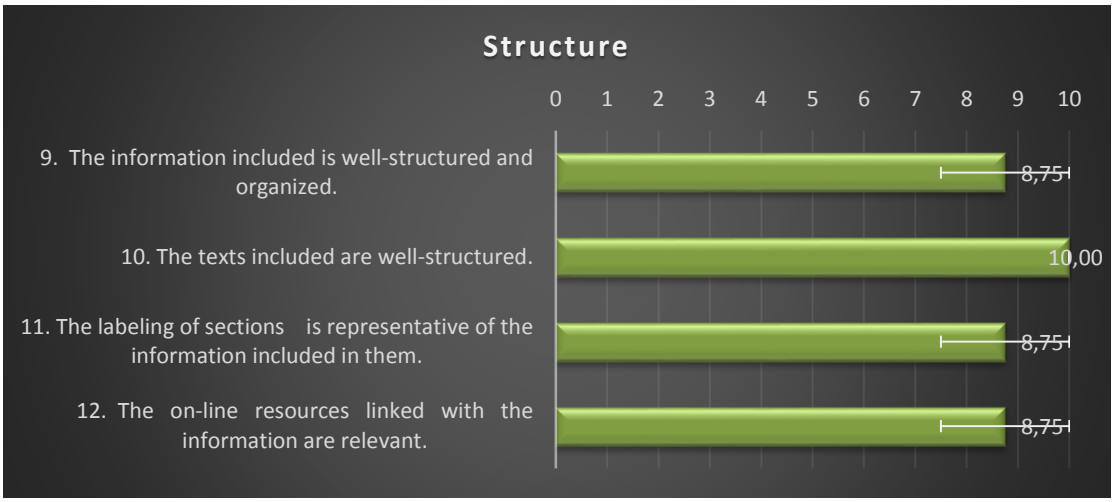

On the other hand the educational materials provided let the teacher to a high degree to set his/her own learning objectives, have access to information and communicate with his/her students.

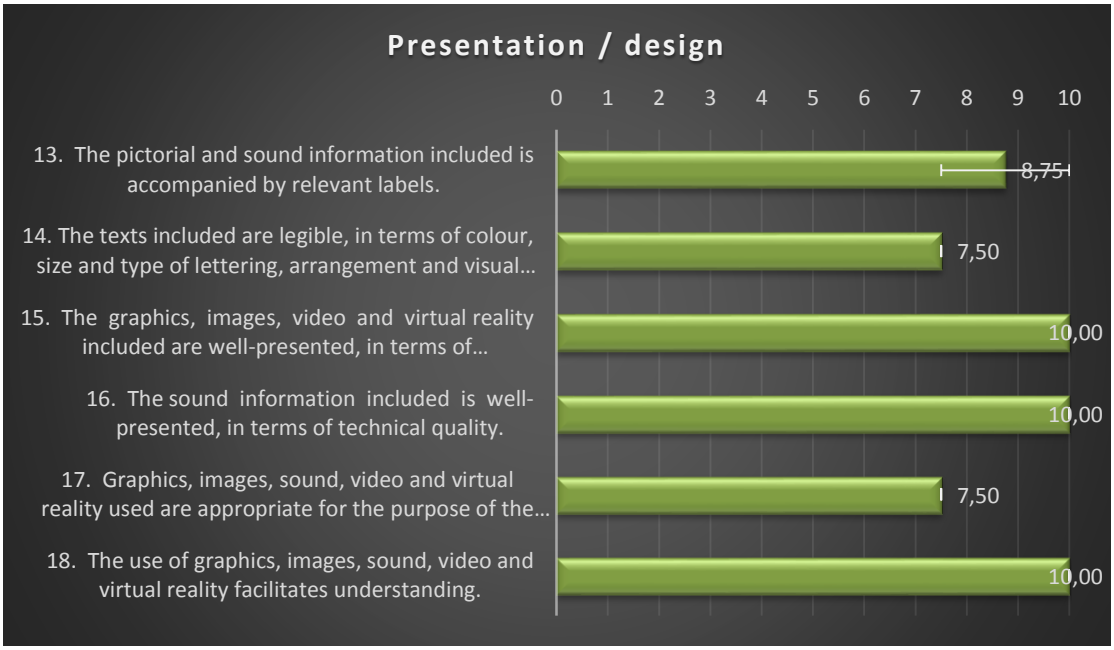
**Content Efficiency**

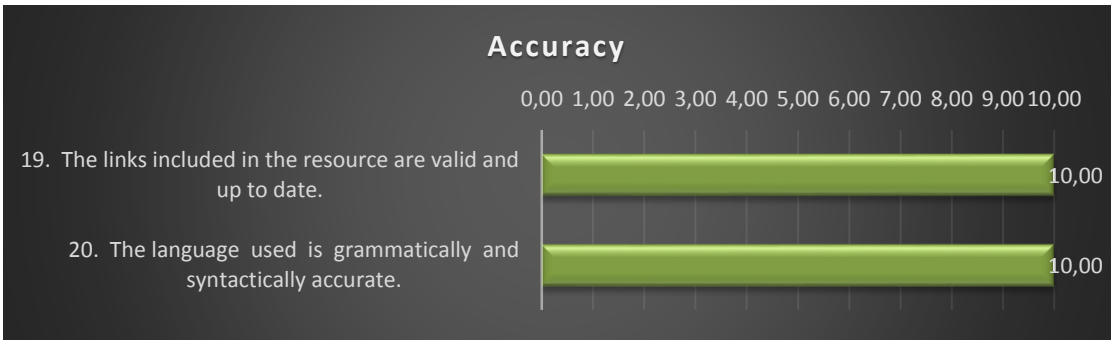
The content efficiency of the Virtual Lab was evaluated with four sets of questions aiming to extract information regarding the Information included, the structure, the presentation / design and the accuracy of the content

Regarding the content of the Virtual lab the graphs below show the teachers' responses.






Both teachers much appreciated the information included as per all different aspects, the structure, the presentation / design and the

**Teacher's Statements**

"Students really enjoyed the interactive animations"

"The theoretical part was a bit tiring for the students since they had little pre-knowledge of the subject matter".

"Emphasize more to why do these phenomena happen" (in regards to physical / chemical properties dependencies on scale)

**CONCLUSION**

The lesson plan "Introduction to Nanotechnology – Nanoscale" let rise the students' interest regarding this science field and allowed them to contextualize some concepts regarding nanotechnology, size and scale and biomimicry.

The students enjoyed the lesson and learned many new things. Some of them had difficulties with the tests but in general, they seem to have a good grasp of the subject. Particularly girls scored significantly higher in most statements even if they had more difficulty with the "Reading before the experiment" part than the boys.

Teachers much appreciated the information included in the Virtual Lab as per all different aspects, the structure, the presentation / design and the accuracy.


*Figure 8: PowerPoint presentation screenshots*

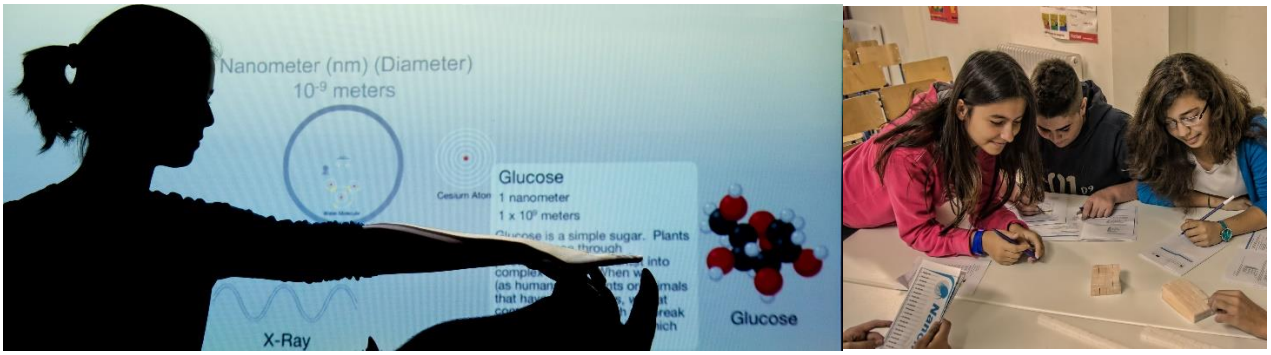



*Figure 9: Implementation photos*