



NTSE – Nano Technology Science Education

Concept paper for the realization of NTSE's Virtual Lab

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1. Introduction

In the framework of the NTSE project it will develop the Virtual Lab, an online educational laboratory that will be a part of the web site of the project itself. The Virtual Lab will aim to support in their learning or working activities the beneficiaries of the project who are represented by students from the 8th to the 13th degree and their science teachers and students from faculties who are the prospective school teachers in sciences.

This text is a concept paper aimed to describe the general features of the Virtual Lab. More than its technical issues, this concept paper intends to focus its attention on the educational methodology adopted in the development of the Virtual Lab.

In order to introduce this concept paper, we would like to start with a consideration concerning the new role that public communication of science has taken on at the end of the XX century, in all of the world.

The society of knowledge represents both the development and the surpassing of the industrial society based on machines and manual work, and which in turn represented the development and the surpassing of the preceding agricultural society, which had been founded on the domestication of plants and animals and manual work in the fields.

The novelty of our era, of course, is not knowledge itself. The cultural evolution of humankind in fact, began with man. Therefore, the production of new knowledge, information and innovative technologies has always accompanied man.

The novelty of our era lies in the fact that the productions of information, of new knowledge and technology that “incorporate endless increasing volumes of scientific knowledge” have become the primary factors “of the innovation, economic growth, international competitiveness and the national economy. (*Luciano Gallino, Tecnologia e democrazia, Einaudi, 2007*)” In other words, in the current society of information and knowledge the production of goods that achieve greater market success is less and less labour intensive and increasingly characterized by high knowledge intensity. The research system is itself a complex system, and thus evolves chaotically, unpredictably a priori, as a result of the actions applied to it. And the results that science gradually acquires represent methodological and cognitive stimuli for science itself which cannot be neglected in the continuation of the investigation.

Research results are translated into action, into formidable instruments of intervention, which mark and heavily influence the development and evolution of the World: its economy, society, values, but also the local, regional and global environment.



Science no longer exists in facts, isolated from society: it means that its progress impacts inexorably the development of humanity and of the world. So science too, can no longer expect that its progress would not be impacted and contaminated by society.

So science no longer should open only to give, to bear fruits, well-being, knowledge.

A science, instead, that no longer has the right nor the capacity to consider itself as a self-referential entity. It doesn't have the right. Because society, which supplies science with resources and is strongly influenced and conditioned by the choices and the results of science, has a right to enter into the decision of the choices that science gives itself. But it does not even have the ability: because if it is true that the evolution of systems is, in many cases, non-deterministically predictable and often not repeatable, then there is no longer (or it is questionable to define) the neutral ground on which the hypothetical dispute between two scientists is resolved objectively, without recourse to referees.

The considerations exposed above highlight that scientific knowledge and innovation, derived from pure and applied research, are the true movers of the economy and development at the present historical stage. This is a huge potential at man's disposal that can be transformed into progress, with positive effects on the life of us all. However a distorted and inappropriate use-which often happens today and will continue to happen while the only criterion adopted as a guideline for choice is the production of profit-may produce unwanted and unsustainable effects, negatively impacting the life of many people, and sometimes of all. Thus it is both right and necessary that the public keeps a close watch on choices and furthermore, is sufficiently informed to do so consciously. Qualitatively and quantitatively correct information is crucial to this aim, that informs on the contrasting opinions of experts: of those who support or oppose the most relevant choices of potential impact, or have strategic global importance or of more local interest. At present the situation in this particularly delicate area is quite inadequate. Mass media, above all, pay scarce and insufficient attention to information on scientific and technological achievements, and even less to the debate on the possible future scenarios differing choices may produce.

Therefore we could start from three remarks that still today are under analysis and testing but are corroborated by so much evidence that our thesis comes out on a good level. The thesis is that public scientific communication has changed its form, ontologically, in the recent past. The three remarks on which it is based are:

- 1 We have entered into a new era of the organisation of men of science. An era that has been defined post-academic (*John Ziman, La verascienza, Dedalo, 2002*). This era is characterised by the



fact that relevant decisions for the development of scientific knowledge, always come from the scientific community in co-partnership with other various social groups.

2 This new era of how the scientists work, brings a new definition to the role of science communication to the non-expert public and what it does for science itself, other than the cultural and civil growth of society. Therefore, the hypothesis is that the public communication of science assumes a relevant role for the development of science itself (Greco, 1999).

3 The system of public scientific communication is a system, dynamic, made up of thousands of different two-way communication channels amongst clusters of different social groups called, in turn, to take on in co-partnership, decisions that are relevant to scientific development (Greco, 2004).

NTSE is a project aimed to improve the knowledge related to one of the most significant scientific and technological issues of the current times, nano sciences and nanotechnologies and its beneficiaries represent the main stakeholders of the educational process in every country, students and teachers.

Considering this reference frame, it is quiet worrying the European situation as effectively resumed in the most recent reports of EU (E.G. Rocard Rapport, 2007) highlighting an alarming decline in young people's interest for key science studies and mathematics. Despite the numerous projects and actions that are being implemented to reverse this trend, the signs of improvement are still modest. Unless more effective action is taken, Europe's longer term capacity to innovate, and the quality of its research will also decline. Furthermore, among the population in general, the acquisition of skills that are becoming essential in all walks of life, in a society increasingly dependent on the use of knowledge, is also under increasing threat.

In consequence, the European Commission has tasked this group of experts to examine a cross section of on-going initiatives and to draw from the elements of know-how and good practice that could bring about a radical change in young people's interest in science studies - and to identify the necessary pre-conditions.

Since the origins of the declining interest among young people for science studies are found largely in the way science is taught in schools, this will be the main focus.

In this context, whereas the science education community mostly agrees that pedagogical practices based on inquiry-based methods are more effective, the reality of classroom practice is that in the majority of European countries, these methods are simply not being implemented.



The current initiatives in Europe actively pursuing the renewal of science education through “inquiry based” methods show great promise but are not of the scale to bring about substantial impact, and are not able to exploit fully the potential European level support for dissemination and integration. (*Science Education Now: a Renewed Pedagogy for the Future of Europe, European Commission, 2007*)

Starting from the considerations above exposed, EC suggests some possible solution:

1. A reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides (IBSE) the means to increase interest in science;
2. Renewed school’s science-teaching pedagogy based on IBSE provides increased opportunities for cooperation between actors in the formal and informal arenas;
3. The role of teachers as key players in the renewal of science education. Among other methods, being part of networks allows them to improve the quality of their teaching and supports their motivation;

Considering a context like the one described above – a context of marked change of the internal dynamics of the scientific world and, above all, in the relationship between science and society – as well as the needs of school - science teaching in particular - deriving from this context itself, it's possible to find strong matches with the aims of NTSE project.

Moreover from this perspective we cannot forget the new technology mass literacy and the fact that Information and Communication Technologies are a sector in continuous rapid evolution. The continuing capillary diffusion within society of new devices and methods means that it must be a lifelong learning process. Due to the effectiveness of these technologies in facilitating different aspects of our daily life (work, spare time, instruction), and because of their ever more accessible cost, their diffusion is spreading with a completely unforeseen rhythm and level of penetration. In this perspective the potentialities of Web 2.0 with its highly interactive features play a crucial role giving a setting and explanation to the production of its Virtual Lab: a modular tool whose contents will be progressively developed in partnership between both its administrators and, first of all, its beneficiaries, teachers and students.

Indeed many of the informational and educational aims of NTSE will be achieved by blogs, forums, chat, social networks, etc. whose management by the project partners will be fundamental but not sufficient. The improvement of the contents of the Virtual Lab carried out by its beneficiaries will represent a fundamental aspect of this process.



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2. Needs assessment analysis

2.1. Curricula Matches

If we focus on the main topic of NTSE, we have to take account that nano sciences and nanotechnologies are quite complex topics considering their relationships with many different basic science subjects, therefore they require quite articulate basic science skills to be faced.

Consequently an important part of the previous work carried out by NTSE partners before ideate Virtual Lab has been a systematic analysis of the curricula in science (physics, chemistry and biology) from the 8th to the 13th degree of the school careers in their own countries. By means of this analysis it has been possible identify those basic science topics that could represent the previous scientific knowledge necessary to face some nano related issues.

These matches between basic science and technical skills and nano related issues represent powerful tools aimed to involve school classes and their teachers from different countries in educational experiences under the guidance of experts both in didactics and in nano sciences.

From the analysis emerged that there is a widespread core of common scientific subjects characterizing the educational background in science for the students of the high schools of each partner country. More complex is to relate the punctual subjects to the age of the students because of the different frameworks of the educational systems in each country. This means that a particular subject is already faced by students of 10th degree in one country while the same subject is faced only on 12th or even 13th degree in another one. This aspect appear particularly complex in Italy where the educational system foresees many kinds of high schools – such as lyceums (humanistic, scientific, etc.) and many different kinds of technical or professional institutes – with their highly articulated curricula in science.

The tables below show some general scientific subjects faced in the schools of the partner countries and some related nano topics recognized by the analysis. To go through this analysis, see Appendix A – Curricula Matches in the different partner countries

Physics

Basic skills	Size and Scale
The nature of physics	
Heat, Temperature and Phase Changes	Preparation of a Cholesteryl Ester Liquid Crystal Thermometer
Properties of matter	Lotus Effect Activity
Electrostatic; Electric current and	Periodic Properties and Light Emitting Diodes



the effects of electricity	
Waves and sound	NiTi Shape Memory Alloy Springs
Structure of Atom	Solid-State Model Kit
Enlightenment	Preparation of an Organic Light Emitting Diode

Chemistry

General and organic chemistry, mineralogy, electrochemistry, radioactivity	X-Ray Diffraction and Scanning Probe Microscopy Solid-State Model Kit Amorphous Metal Activity Citrate Synthesis of Gold Nanoparticles:
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Biology

Botany and zoology	Preparation of an Organic Light Emitting Diode (related to photosynthesis) Nanowire sensor slides
Genetics	DNA Optical Transform Kit
Vegetal, animal and human physiology	DNA barcode slides Quantum Dots

2.2. Analysis of the questionnaires

Besides the analysis of the curricula described above, in the spring 2011 the partners elaborated some questionnaires addressed to samples of people representative of the main beneficiaries of the Virtual Lab. The questionnaires were aimed to recognize the opinions of the beneficiaries concerning several different aspects of their activity investigating on three main thematic areas in order to better define the features the Virtual Lab should have: ICT, scientific contents and educational methodology.

The questionnaires have been submitted in the Months of July and August 2011 to samples of beneficiaries respectively in Turkey, Greece and Romania (students, teachers and perspective teachers), Bulgaria (teachers). These analysis represent both a tool for the development of the project and also an interesting compared study about the needs and the opinions of the main stakeholders of the educational system of different countries.

Below are briefly described the most relevant issues emerged from the analysis of the questionnaire. To get quantitative data about the results of the questionnaires, see Appendix B – Questionnaires results reports in the different partner countries.

Students

The majority of the students considers as the most interesting subjects the ones related to the



sciences of Life as well as to the new technologies (like robotics and so on).

The students acknowledge the importance of science in society and in their life even if they consider sciences less interesting than other subjects and also difficult to face.

The students think that the best way to make easier the learning of science is an experimental approach like performing real experiments, having direct contacts with nature or, secondarily, enjoying simulated experiments on virtual labs and the like.

A very large majority of them (over 80%) prefer computers and Internet to learn and discover aspects related to scientific topics. They consider video clips and virtual experiments as the most effective virtual tools for this aim.

Finally a majority of them consider that the most enjoyable environment to learn and discover about scientific topics could be a virtual platform devoted to this aim, while a secondary but still relevant percentage of them consider enjoyable environment social network (like Facebook) or forums and group discussion.

Teachers

In each of the country where teachers were interviewed the gathered results seem to confirm the ones emerging from the students' questionnaires.

The majority of teachers consider the topics related to the improvement of human life - under the point of both the health and the new technologies in daily life – as the most appealing for the students.

The results about the extracurricular topics that should be integrated with science topics are more articulated. Indeed a widespread range of different topics find the interest of the teachers. Among them we can mention environmental topics (garbage treatments, energy saving, etc.), human health related topics, new technologies and so on.

The majority of teachers in all partner countries declare that they have some knowledge of nanotechnologies, while results concerning what curricular topics teachers consider as related with nanotechnologies are; atom, molecules and chemical bonding, structure of DNA, genetic studies, heredity and how genes influence how we develop reproduction in humans, technology and its interaction with science, chemicals, their properties and how they react, parts of human body and how the systems work, the structure of cell, mitosis and meiosis, optics and how they are used in our daily lives.

With quite relevant differences among the samples interviewed in the different countries, many



teachers think that science education should show how what the students learn in classroom is related to external world and daily life, should make the students able to perform experiments, should enhance the personal interest of the student toward science, use information technologies (ICT), offer short reports on modern achievements in science at the micro- and nano-level by short talks in every learning unit to raise the awareness related to the nanotechnology.

More homogeneous are the results concerning the opinion of the teachers about the most effective modern ways to learn a scientific topic. Among the most rated of them we find the direct performing of quantitative experiments, the use of interactive computer based tools and secondarily the watching of educational clips even showing the performing of experiments.

The majority of the teachers consider that videos (%66,72), procedures to carry out the experiments with the students (%65,49), images (%62,62), and simulations (mainly interactive simulations) are important for an online virtual lab.

From the results of the questionnaires emerges also that teachers consider very important that student analyse the observed phenomena in a critical way formulating their own explanations, communicating with other their experiences and finding relationships with other phenomena and topics.

Finally, the most of the teachers affirm to be well skilled in the use of ICT, and to use often ICT and ICT based products in their teaching activity.

Prospective teachers

The majority of the interviewees affirm to have just knowledge about basic concepts or even to know just what nanotechnologies are.

The majority of them think that emerging sciences like nanotechnologies should be taught in required or elective courses just in high schools. The relative majority of chooses changes between Romania and Turkey. Romanian (%35,48) and Greek (%30) interviewees think that it should be a required course while %100 of the Turkish interviewees and %40 of the Greek interviewees believe that it should be an elective course for only high school.

A relative majority of the Romanian interviewees (% 35,48) think that just the basics of nanotechnologies and some reference application fields should be introduced in primary schools while 40% of the Greek interviewees believe that the best is just to regulate some field trips for the students to high technology companies and 33,33% of Turkish interviewees think that only the basics of technology and some application fields should be introduced to only self-interested students by using a virtual lab.



A relative but higher majority of the Romanian interviewees think that also in high schools just the basics of nanotechnologies and some reference application fields should be introduced while a lower per cent think that it should be provided a complete training about this topic. In Turkey two relevant percents of the interviewees (both a little over 30%) believe that in high schools respectively just the basics of nanotechnologies and some reference application fields should be introduced, or education of nanotechnology should be only for self-interested students by using a virtual lab.

The majority of the Greek and Romanian prospective teachers believe that a complete theoretical training should be taught to the teachers while the majority of Turkish prospective teachers consider that only the basics of the nanotechnology and some application fields should be introduced to the teachers.

In both the countries the absolute (Romania and Greece) or relative (Turkey) majority of the interviewees consider that the most effective way to learn sciences is watching video clips or documentaries. Anyway the majority of Romanian and Greek interviewees consider the effectiveness of performing experiments and the use of interactive PC based tools, while an important percent of the Turkish interviewees esteem formal lesson and the reading textbooks.

The absolute majority of the interviewees consider procedures to carry out experiments with students, interactive simulations, generic simulations, videos and images as important tools for a virtual lab.

In Romania and Greece the majority consider that inquiry based laboratory activities represent the best lab approach but a large even if lower part of them consider effective also cook book based laboratory activities, while in Turkey the results seem the opposite with a clear preference for cook book based laboratory activities.

Regarding the activities in a laboratory and considering that available responses are not exclusive, the results are very articulated. In all countries emerged that students should be able to access the on-line experiments that cannot be done in a laboratory. In Romania emerged also that they should be engaged by scientifically oriented questions and they should have (be provided) the ability to expand upon their findings and relate those findings to similar situations. In Turkey and Greece instead emerged that they should have (be provided) the ability to communicate their experimental findings to others in class via written laboratory reports, and should have (be provided) the ability to formulate their own explanations from the evidence they have obtained.

All the available responses concerning what's important for the students if they realize their own



laboratory are well represented: students should be able to make observations, pose questions, communicate results, identify assumptions, consider alternative explanations, propose answers, explanations and predictions, review what is already known by experiments.

The relative majority of the interviewees consider good their skills in the use of ICT

A relative majority intends to use Power Point presentation for leading Nano-tech experiments in their future lessons while a lower but still relevant number of them intend to use virtual experiments and video clips to do it.

The large majority consider ICT tools as a source of inspiration for them as a future teacher and as a way for improving students' understanding Science/Nano-Tech topics, and also as a method for improving students' learning skills.

Finally from the analysis emerged that the majority of the interviewees consider ICT very important tool to promote of inquiry based/creative learning about Science/Nano-Tech topics, and appreciate the effectiveness of communication by means of ICT for the teaching of the same topics, as well as they believe that ICT tools are quite important as a channel for guiding students to explain scientific aspects and propose hypothesis for investigation and that ICT tools are quite important as a way for better planning of an experiment.

Moreover in all countries the interviewees affirm that for teaching Science/Nano-Tech topics ICT tools represent a method to increase students' motivation and to make learning more attractive.



3. Methodology, Educational Criteria of NTSE's Virtual Lab

This paragraph describes the educational methodology that will characterize the Virtual Lab. The main idea is that the educational proposal of the Virtual Lab should promote the adoption among its beneficiaries of the “scientific method” as a way of learning and acting.

Scientific method – whose modern definition hasn't got still a completely univocal features – is the result of an evolving process whose roots could be found in the birth of the first civilizations. However with Galileo Galilei scientific method acquired a precise definition so that many aspects of Galilei's methodological approach are still unanimously accepted by scientific community.

Galileo Galilei first introduced the formal concept of scientific method and many of the criteria he proposed are still considered efficient in modern science. His approach avoided the research of previous “essences” and “qualities” – as usual among his predecessors – and focused the attention on the empirical observations so much to consider as “science” just the knowledge gathered from experiences. This is the crucial point that could represent the link to move scientific method from research to education.

In this perspective, if we would employ a scientific approach in an educational context, empirical observations are the main features on which we have to focus our attention. Even if we can't expect that a student can contrive his own scientific knowledge starting just from deductions based on empirical experiences, however we can expect that empirical experiences, focusing student's attention on really observed phenomena, could at least help him to develop a constructive critical sense clearing from misconceptions and previous beliefs the inquiries he carries out.

Therefore empirical experiences should rather represent a powerful tool aimed to integrate formal learning in science (and not only).

Indeed as far as scientific method is concerned, we will make two quite relevant considerations. The first is that the scientific method is substantially applicable not only to the *generation* of new inter-subjective knowledge; also it is an effective tool for its *transmission*. So it can be considered also as a powerful educational instrument.

The second observation deals with that particular step of scientific method consisting of organizing observations within an abstract axiomatic-deductive scheme. We could even renounce the idea of formalizing such a scheme in mathematic terms, expecting only that it is a coherent and organized scheme of logic, then the same methods can be applied to research and didactics in natural disciplines (usually labelled “scientific”), as to research and didactics in every other discipline



(historical, philosophical, linguistic, etc.).

In this regard, from the point of stimulating the attitude to participate actively in the production of inter-subjective knowledge it is not important *what* one learns or teaches, but *how* one learns or teaches.

To this end the following paragraphs in italic provide a description of two strictly related concepts – non formal education and IBSE – representing the most significant educational approach that NTSE project intend to apply in development of its activities.

Non formal education is represented by all these kinds of organized educational activities out of the field of formal education according with curricula recognised by Ministries of Education. European Union acknowledges them – on the same plane of formal education activities – as tools to reach the so called “8 Key Competencies”. Despite of this point, not everywhere in Europe non formal education is considered equal with formal system. For instance in Italy non formal education activities are carried out by organizations that could provide just certificates of attendance but non official qualifications.

IBSE (inquiry Based Science Education) represents a significant example of non-formal pedagogical approach promoted by European Commission (Rocard Report, 2007, see above) based on investigation and aimed to stimulate questions and actions to solve problems and explain phenomena. This approach considers an innovative series of phases in respect to ways of teaching: learners face with the object of study (e.g. a biological or physical phenomena, measurement tools, etc.), formulate questions and hypothesis, verify them by mean of experiments and talk over the gathered results.

In order to apply this approach at school is recognised the so called “5E model” that consider an IBSE activity as distributed in the following phases: Engagement; Explore; Explain; Elaborate; Evaluate.

Engagement

An activity starts always observing phenomena in the framework of the educational task. Students are invited to reflect and pose questions. Moreover during this phase students are free to express their opinions and observations and the teachers should collect the most significant among them.

Explore

once the questions have been collected, students are addressed through the experimental phase asking them to ideate an experiment that could provide answers. The teacher should be ready to get



suggestions and proposal even by the students who want to explore the phenomena in an alternative way. Anyway is fundamental the students recognize crucial variables and experiment them.

Elaborate

students elaborate the gathered results and apply the experience to other situations that could let rise up new questions and hypothesis to be explored. Now the students should reach the so called “transfer of learning”.

Evaluate

this last phase forecast the realization of a final product that will be evaluated by means of self-evaluation, evaluation among peers and evaluation by the teachers.

It is important to highlight that the phases described above doesn't be considered necessary consecutive.

Concerning “how”, our suggestion is clear with the above mentioned reference to the scientific method. Concerning “what”, our suggestion is a balance between global and local horizons.

Consulting a common dictionary, we can find a simple definition of science: «Science is the complex of human activities designed to know, through experience and reasoning, the world, its laws, its causes and its general principles.»

Thus: experience and reasoning.

Experience means the observation of a phenomenon, object of study, thus acquiring knowledge about the phenomenon itself, and quantifying it into numbers, whenever possible, through measurement. Not until we see, we know anything; and as a consequence, it would seem that experience and reasoning follow one another in this order: first observation and then reasoning on the results of the observation. Actually fact, the two moments proceed in close interaction with one another.

Let us use an easy experiment – even if absolutely not “nano related” - as an example: a school class wants to determine the shape of the classroom floor.

The classroom is made up of building materials (cement, bricks, etc). If we had to question its structural resistance or its thermal efficiency, its brightness and so on, we would consider many properties (mechanic, thermal, optical...) of its components (walls, floor, ceiling ...). But, we are simply interested in determining the shape of the floor that can be represented approximately as a portion of a plain surface, contained by four sides (segments), each one having its own length, and forming angles with contiguous sides. Saying this, building materials of the classroom, have been represented, according to our aims, through abstract entities (segments, angles, surfaces ...) framed



into a logic-deductive castle known as “plain Euclidean geometry”, ruled by laws and theorems. Let us remember and stress that geometrical entities (segments, angles, circumferences, polygons...) are not material objects. They are abstract entities that represent properties or aspects of real objects and yet may be measured and so quantified with a number. At this point in the experiment - at this point in the scientific enquiry - the pupils can use a tape measure to measure the four segments forming the sides of the quadrilateral that represents the classroom floor.

Let us suppose that as accurately as we can ascertain that the four sides have the same length. Then the shape of the floor is still not determined unequivocally. An equilateral quadrilateral may be in fact a square, but even a rhombus. In order to remove the doubt, we have to measure one of the inner angles. By using known geometrical theorems related to quadrilaterals, the value of the other angles may be calculated without further measurement. In particular if the angle measured was 90° , the remaining three would be 90° , too. It is possible and probable that the school – which has no problems in measuring lengths – has some problems in measuring angles. In this case, the doubt may be removed by measuring the two diagonals. If one is equal to the other, we have a square. In this case, considering that a diagonal divides the square into two right-angled triangles, whose hypotenuse is the diagonal of the square, its length may be calculated using the Pythagoras’s theorem, allowing us to verify if the forecast is correct.

As we have seen, although simple, our experiment has been conducted utilizing interactivity, close observation and reasoning.

It is our direct experience that a student, led by the hand to perform an experiment, as easy as the one just outlined together with his schoolmates, will receive a positive input that will accompany him throughout his entire learning process.

How much greater this input would be, if the teacher brought alive the emotion of discovery pushing the student to imagine that he is Eratosthenes, who almost two thousand years before Columbus, demonstrated with simple tools, that the Earth is a sphere and calculated its radius. Or take Galileo Galilee, who had an intuition and then demonstrated by an experiment that any two bodies fall together by the action of the laws of gravity; again, Galileo when using his inclined plane and little bells laid down the foundations of the whole of classic dynamics; and Archimedes when he exclaimed “Eureka!”. These are just some examples that a smart teacher could suggest to his classroom, employing simple instruments that most of today’s children find at home, or even in their pockets.



If we focus on the main topic of NTSE, we have to take account that nano sciences and nanotechnologies are quite more complicated topics than a simple experience in plain geometry or in basic physics, topics requiring quite articulate basic science skills to be faced. Anyway we can assume that the process described above is representative of the operating educational criteria we would promote among NTSE beneficiaries.

For instance, we could imagine providing to NTSE beneficiaries all information needed to reproduce a nano related experiment beyond some basic information that could allow them to explain the phenomenon or to foresee its evolution, and so on.

Now we don't care if the beneficiaries will face their challenge by an analytic but (we hope) correct interpretation of the observed facts, or by carrying out a research on books or in the web. The main goals will be the educational effects of such a “research” experience on its beneficiaries.

Anyway it's obvious that the Virtual Lab will provide to its users also deeper and rigorous scientific information (see paragraph 5.3. *Repository*) in order to let them investigate the proposed experiences.

For a more detailed description of the experiments and the experiences that the Virtual lab will propose to its beneficiaries, see the paragraph 5. *Functionalities of the Virtual Lab*.



4. Topics and contents of the Virtual Lab

Top rated topics from the beneficiaries

As already said above, from the analysis of the questionnaires emerged that sciences of Life (and mainly their related knowledge aimed to the improvement of Human) life as well as to the new technologies (like robotics) especially if related to daily life are the most appealing subjects for both students and teachers.

Apart of this point we have also to consider the kind of educational experiments and nano related experiences already available (for instance, because already developed in the framework of other educational projects or because faced by means of special educational kits like the one related to the science subjects in the curricula matches, see above) or that could really be performed by the beneficiaries or showed in a virtual environment.

Therefore it will be very important to emphasize the links between daily life and the experiments and the experiences proposed in the virtual lab independently of the way to show them and of their less or more theoretical features.



5. Functionalities of the Virtual lab

The general framework of the Virtual Lab (of NTSE's web site)

The Virtual Lab will be an articulate section of the NTSE project web site which first draft is already existing (<http://www.ntse-nanotech.eu/>). In the framework of the web site, the Virtual Lab represents a section expressly aimed to the communication of the educational contents to the beneficiaries of NTSE, students, in job and future science teachers.

Actually the first draft of the NTSE's web site is completely in English, but it could foresee the development of more sections in the different languages of the partner countries. Anyway international cooperation and European citizenship will represent an important point of the activities of NTSE, therefore the experiences proposed in the Virtual Lab will be also aimed to promote a common environment in English language.

It's important that under its structural point the Virtual Lab will show clear analogies with the framework of the project itself in order to facilitate the beneficiaries in understanding activities proposed by both Virtual Lab (educational activities; virtual experiments; etc.) and the project itself (competitions; educational camps; meetings; etc.).

From the considerations emerged from the projects meetings already carried out and from the results of the needs assessment analysis, it's foreseen that the Virtual Lab will be parted in several rooms with different aims and functionalities as described below.

5.1 Nano Tech Experiments room

This room will represent the educational core of the VL because it will provide to its beneficiaries all the information needed to carry out nano related experiments. These information will consist in practical materials as step by step scenarios (lesson plans, courses), texts, PPTs, videos, resources, guidelines for both teachers and students, etc.

In particular in this room will be proposed the educational experiences described below and developed in the framework of other European projects or other educational initiatives.

The experiments of the Nanokit – The Nanokit is an educational products developed in the framework of the project TimeFourNano (2009-2011, Seventh Framework Programme) and consisting in a box containing a set of tools listed below and aimed to carry out some nano related experiments and educational experiences.

- Activity 1: How tall are you in nanometres? This activity aims to help you understand how small a nanometre is;
- Activity 2: Dilution. Here you discover that our sense of smell allows us to experience



- nanometresized things that are too small to be seen with our eyes;
- Activity 3: Magnetic probe. Demonstrates the tool used by scientists to observe and work on the nano world;
 - Activity 4: Make your own buckyball. Lets you build a 3D model of a nano object, the 'buckyball';
 - Activity 5: Ferrofluid. Shows a peculiar liquid that behaves like a solid when it's under a magnetic field;
 - Activity 6: Magic sand. Allows you to discover a curious type of sand;;
 - Activity 7: Hydrophobic textile. Where you will discover a fabric that repels water;
 - Activity 8: Anti fog. Will show how it is possible to avoid condensation on your swimming goggles;
 - Activity 9. Memory metal. An extraordinary kind of metal with strange properties is described.

Some of the experiments of the Nanokit will be proposed in the Experiments room in order to be replicated by NTSEs' beneficiaries. In particular will be privileged the experiments whose execution requires easily available tools and materials.

Wisconsin University Nanokits experiments – these nanokits have been developed for educational aims by the Interdisciplinary Education Group of the Wisconsin University. The kits face several different aspects of nano sciences and nanotechnologies. Turkish partners of NTSE supported by their scientific consultant will choose a group of selected activities among the ones proposed by Wisconsin University's Nanokits and will adapt them to be proposed in the Experiments room. Below are listed the main significant nano related kits produced by the Wisconsin University which were chosen by the Turkish partners:

Synthesis of Silver Nanoparticles

- Disassembly of a Liquid Crystal Watch
- Nanoparticles and Quantum Dots
- Polyhedral Model Kit
- Activity on prepared solar cell
- Exploring the Nanoworld Kit
- LED ColorStip Kit

Novel nanotech experiments will be discovered by Turkish partners of the NTSE and they will be included in the virtual lab



5.2 Broadcasting room

This room will be aimed to provide and share experiences carried out in the framework of the project in the guise of multimedia product as video clips, images, etc.

We would remember here also the large availability for everybody in contemporary society of cheap and effective multimedia tools as photo and video cameras – as well as PCs with their varied devices - that could allow the beneficiaries to document and share the experiences carried out. The documents produced by beneficiaries as clips, hypertexts and so on will be filed in this broadcasting room and so made available also for a wider public of less involved beneficiaries.

The documents produced could represent also evaluation materials both for the educational effectiveness of NTSE and for the participation of beneficiaries to the Nano Camp that will take place in Varna (BG) during the third year of project.

The broadcasting room will host also materials produced by NTSE work group represented by interviews to experts, scientists, educators and so on.

Moreover in this room will be prepared special Web 2.0's pages (in social networks, in forums, broadcasting channels, etc.) that will allows beneficiaries of NTSE to share the educational nano related experiences carried out in framework of the project as well as to exchange opinions and ideas about results and so on. Another important point that we have to face is the national or supranational dimension of these experiences.

The Web 2.0's pages (in social networks, in forums, etc.) will allow involving beneficiaries from the different countries in common experiences scheduled in NTSE project. This last point highlights a secondary but still important aspect related to content and language integrated learning (CLIL).

The registered users of the platform will be able to make live video conferencing which will be recorded and uploaded to the broadcasting room in order to share their experience with other users.

5.3 Repository of nanorelated educational materials and glossary

Another significant educational aspect of the Virtual Lab will be the repository of nano related educational resources and this task will have a devoted section articulated in more sub sections. In this section will be collected a list of nano related educational resources already available in the Web (educational sites; science journals; online multimedia tools; etc.) and nano related educational tools and materials (texts; multimedia; applets; etc.) already existing and free downloadable. Considering that such kinds of material are available both in English and in the languages of the different partner countries, we could foresee to realize more repositories for educational resources



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respectively reachable from the common section of the Virtual Lab (in English) and from the sections in the different languages of the partner countries.

The information available in this room will be linkable from the Experiments or the Broadcasting room if they will be useful to better face the subject proposed in these two sections. Similarly the Repository room will provide links to both Experiments and Broadcasting rooms when they will be appropriate.

The repository room will host also a glossary containing a list of nano related words with their definitions and related scientific information aimed to facilitate the carrying out of the proposed educational activities.