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BEITRÄGE ZUR LEHRERFORT - UND WEITERBILDUNG

ISSUES ON TEACHERS' IN-SERVICE TRAINING AND FURTHER EDUCATION

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Physics and Didactics: A creativity based proposal for primary teachers' in -service training

Education in Science and Scientific literacy

It is well known that a fundamental target of education is to prepare free active citizens, members of a democratic society. That is, citizens who will have essential awareness in all matters that concern them, at least to a certain point and who will be capable of devising and producing new knowledge in all sectors of human activity. By having critical thinking they will be able to make decisions which come up daily either in private or social levels. (Kokkotas, 1997). The fulfillment of the goals of education has as a result (Xanthakou, 1998) the emergence of the person's latent abilities on the one hand, and on the other hand the development of the appropriate educational environment so that well-aimed didactic interventions, favoring personal integration, will exist.

Based on the above context, the targets of Didactics of Science are established. There are many arguments which support the reasons why pupils should be taught Science, some of which considered as the most important are discussed further on. The first of these is the utilitarian argument (Solomon, 1993) according to which economical power, progress and the well-being of modern societies are due to science and technology. Therefore education should provide the necessary scientific knowledge, in order to convince yet more young people to be involved in science so that the technicians and scientists of the future can arise from them. As a second argument Millar R & Osborne (1998) mention that young students should get acquainted with science, so as to acquire essential knowledge regarding their surrounding world because it is interesting and important, but simultaneously to feel the satisfaction which scientific knowledge can offer. Finally, the democratic argument, according to which understanding of the nature of science is necessary for people to perceive socio-scientific issues and be able to partake in decision-making. Also, Millar and Osborne (1998b) claims that:

«The continuously augmenting effect of science in daily life requires that the total of the population be able to perceive scientific matters appearing in current events, and be able to deal with the changes which science and technology impose on individuals as well as society».

According to Aron (1992) as well, a person involved in Science and Technology usually develops an attitude, which, among others, presents the following characteristics:

- Recognition of concepts in cognitive fields of Science as creations of the human mind and not coincidental discoveries.
- Recognition that understanding and correct use meanings demands that they be defined in a liturgical manner (use of experience and simpler definitions).
- Understanding the difference between observation and conclusions and discerning them regardless of the frame in which they occur.
- Accepting the planning of cognitive strategies for the formulation and the examination of hypotheses as a normal scientific research procedure, as well as the important an different role of accidental discovery.
- Discerning between personal opinion, aspect, or reputation without any scientific base and the scientifically proven knowledge.
- Understanding what a theory is within the limits of Sciences and the fact that such a theory is formulated, examined, evaluated and temporarily accepted.
- Knowing examples, which indicate that concepts as well as theories have a variable character undergoing a constant content enrichment and refinement.
- Accepting that scientific search has limits and that within these there are questions which can be set or answered.
- Studying in order to increase knowledge in the scientific areas of interest, thus being able to approach new topics without the constant need of instruction.
- Knowing ways/examples with which scientific knowledge and methodology equips man with a powerful observation instrument, of the universe, as well as the his/her own position in it.
- Perception of the existing interaction between science and society, as well as the existing analogies between ways of thinking in Science and Humanities.

And if we actually accept that the development of a society is determined, among other factors, by from the cognitive level of science and technology, which it acquires and utilizes, we are led to the observation that scientific and technological literacy of citizens reflects its level. Therefore, justly, quite a few years ago, Reid and Hodson (1987) point out that: "the understanding of meanings and laws of Sciences, and their accomplishments and limits, and the improvement of this understanding is not a luxury, but a vitally important investment for the well-being of our society" (Kokkotas, 1997 p. 102).

And since the intentions are well-defined, how do the recipients of these intentions feel?

How do pupils feel and which are their attitudes regarding Science when they graduate from secondary education? How essential is the knowledge they acquired and are able to use, to study new problems and acquire new knowledge by understanding ts technological applications in depth? Studies indicate that pupils are indifferent and have a negative attitude towards Science, a situation which is valid even for those with high grades (Chalkia & Karanikas, 1998). In spite of the time devoted to the teaching of Sciences in Elementary, Junior Secondary and Senior Secondary Schools, it seems that (Psyllos, Koumaras & Kariotoglou, 1993, Kokkotas & Karanikas, 1994, Karanikas, Kariotoglou & Kokkotas, 1996, Ioannidis, Garifallidou & Vavougios, 2001, Chalkia, 2001):

- Pupils don't easily change their opinions, keeping many of them and returning to older "optional" view-points, after a while and despite the school teaching they received
- Pupils mainly choose to learn things by heart within the limits of the curriculum, without ever learning in depth and finally
- Pupils refer to "methodology recipes" to solve problems which they seem to forget very rapidly.

From the high failure ratings in entry examinations it is perceived that pupils do not have sufficient thinking abilities to be able to face even the elementary and often average difficulty problems, which require the application of Scientific methodology, a situation which reveals a peculiar illiteracy in Science (Chalkia, 2001). Research regarding primary education students seems to provide similar results. The percentages of students with little to completely insufficient knowledge who cannot apply it to solve problems or who express thoughts with the help of optional mainly perceptions, whose processing and utilization is part of the Didactics of Science, is extremely high.

Examining the level of understanding of concepts in Science of ordinary people in Greece, Europe more widely (EUROBAROMETER, 1993, Physics on the stage, 1999) and in the USA (Project 2061), we conclude to a high percentage of illiteracy in Science. A series of results derive from the aforementioned situation (Vavougios, 2002), some of which are:

- The incapability of following scientific development

- Passive use of technological applications and technophobia
- The one-sided accepting of negative effects of the use of Sciences, computers and technology in general.
- Failing to appreciate that the increase of human wealth and the improvement in biotic level of humanity results from the application of Sciences.
- Ignorance of the causes and reasons, which impel «specialists» to propositions and making decisions.
- The democratic vote of citizens who are not informed about the scientific essence of questions and problems, for which they are voting. Citizens of this category can subsequently easily be made victims of propaganda of various financial and other interests.
- Lack of understanding of the interaction of science and society.
- The non-acceptance of science as part of the universal intellectual civilization.

Yet, a high percentage of all these (pupils, students, as well as simple citizens) managed to succeed in their exams, although they were examined through the traditional teacher-centered system, that requires mostly pure memorization. Based on the Greek data, it is highly possible that they had exceptional grades in Science. The question set at this point is: what do, finally, high grades at school correspond to, since they do not seem to correspond to functional knowledge of Science? What do we consider as teaching, which has achieved its goals in education in general and in Physics or Science specifically? How can we conquer such a success?

What makes teaching of Science special?

Physics is one of the "oldest" sciences of mankind and it deals with the study of nature and the characteristics of material bodies and systems, as well as the forces responsible for the interactions among them as well as between them and their environment. The natural world is an unending source, from which thinking human beings, such as researchers, draw their necessary knowledge. Regarding Physics, acquiring of knowledge (Verganelakis, 1985) is achieved with the aid of the appropriate method, which is based on both observation and theoretical analysis as well as laboratorial-experimental work. Experimental work provides the researchers with the possibility to re-examine natural phenomena gaining further knowledge and experience concerning them. It also provides them with a "way out" for their mental incentives, in the sense that they can hypothesize, experiment by trying with success or failure, construct models and theories using the language of mathematics, finally pinpointing those which correspond to the under observation natural system or phenomenon. They manage to explain the results of their experiments and to foretell new natural behaviors successfully. Lately, scientists have found computers to be important assistants in their attempt (Kalkanis, 2000) through which, simulation and visualization of the behavior of various categories of natural systems is achieved, especially those whose laboratorial study is difficult to impossible.

Rational thinking, inspiration, fantasy, curiosity about "why does it happen...." Or " what would happen if...." co-reside in the mind of the Physics researcher and intercept each other in the same logical-natural environment, resulting in the expression of this creativity through the materialization of mental and empirical results. Every phenomenon or system which does not "fit" within the limits of an existing theory demands the devising/creation of a new one and every thought or even just a description which is incomplete demands its integration. Scattered ideas and results from different research papers submit to wider classifications, which, in turn, give up their places to wider mental explanatory shapes. Wider areas of knowledge are opened up and mental irritations light the spark for the inventing of new experiments, which can sometimes be characterized as ultimately different or/and innovating compared to the previous ones, obeying totally different logics, but necessary to prove the correctness of the theories they are testing, as being conducted is testing them themselves. The new widened knowledge, just as any other knowledge in the area of Science, which has originated from a well expressed problem whose solutions have undergone objective experimental procedure is correct within the limits of power of the theory which covers the relevant model of the problem. Since with the experimental work and the theoretical analysis the limits of knowledge are expanded (Verganelakis, 1985), new appliances, instruments and techniques make their appearance giving in turn solutions to both specialized technological problems correlated to the research attempted, as well as problems of everyday human life leading to the production/creation of goods and services. How could we characterize the way of thinking of researchers of Sciences? Working with the nowadays valid body of knowledge in Physics, which is characterized not only by the actual knowledge it consists of but also the methodology[1] through which they were gained it seems that it can define ways of life and intellectual activity[2], as long as the adoption of its logic implies thinking[3] which is simultaneously critical and creative, evaluating and independent. This same well-defined body of knowledge accompanied by its effective methodology can be used (Verganelakis, 1985) undergoing appropriate specialization from similar scientific fields contributing to their development. We could mention, as a characteristic example, the contribution of physics to the development of material science, telecommunications, medical representation techniques, computer development, etc. Furthermore, Physics as a science affects human intellectual civilization deeply by assembling a powerful liberating force of human intellect (Verganelakis, 1985, Xanthakou, 1998) from all sorts of dogma, suspicions and prejudices determining models of action and intellectual production.

In the following diagram the scientific method is coded and summarized. The normal course proposed through this and method and its steps towards the conquest of knowledge are usually not followed in the educational process (at school and at university), but on the contrary, it is reversed ending up in a dogmatic process where everything is known from the start, the experimental verification conducted simply and the applications work in the best possible manner

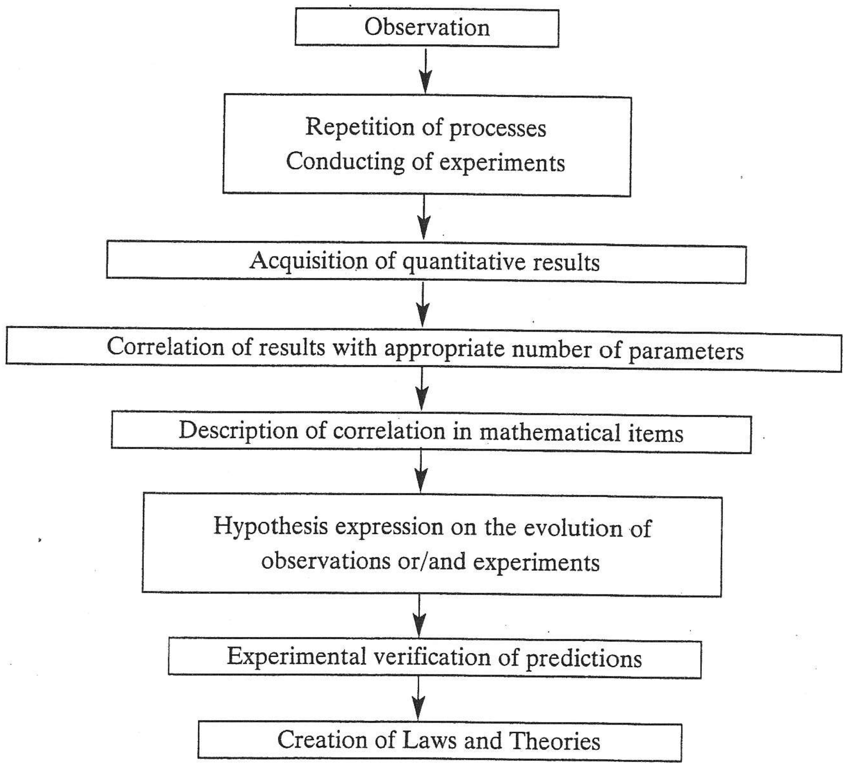

Figure: The scientific method and its steps
(*Source*: G. Th Kalkanis & D. I. Kostopoulos. Physics, From the Microcosm to the Macrocosm, I.α Mechanics. Athens 1995)

At this point, if it is supposed that we are ready to help our pupils to use the instruments of Physics (observation, experimental research and mathematical expression) correctly to study a series of interesting topics. What results will arise?

Use of tools requires certain dexterities, which Science Researches have, but pupils and students do not necessarily have too. Research in the Didactics of Science has shown that the in depth study and understanding of natural systems requires abstracting approaches which are materialized with the help of mathematics. It is believed that the appropriate ages (Beth & Piaget, 1966 in Chalkia 2001), when such processes obtain meaning, are those of the last secondary school classes. It should also be noted that the difficulty of these approaches discourages students and makes them choose easier explanatory models, which usually constitute intellectual patterns based mainly on alternative ideas. As a result we have the exceptionally great difficulty of changing (Driver 1989) such empirical attitudes and their replacement by correct explanatory models.

Further interesting factors which affect the teaching of physics and make it a complicated phenomenon is the need to exceed sensory data, the communication language/code when expressing the research results as well as that which is used in the classroom (Solomon, 1987, Guiraud, 1989, Vavougios & Papadopetrakis, 1992, Sutton, 1992, Chalkia, 2000); the teachers attitudes towards the subject and its teaching process (Arons 1992); the way "solving problems" is introduced by them (Gott & Mashiter, 1994, Whitebread, 1997); and finally the curriculum (Hameyer 1991, Klein, 1991, Kouledis, 1994, Koliopoulos 1997, Kariotoglou & Tselfes, 2000, Koliopoulos & Ravanis, 2001, Tselfes, 2001, Chalkia 2001).

What we can do, to help pupils understand Science

One of the simple, essential but also difficult questions which should occupy the elementary and secondary school teachers the university researcher and everyone, in general, who is involved in the planning of the country's educational policy is the following (Tselfes, 2001):

"What pupils should remember, what they should understand and what they should be capable of doing when they complete their schooling".

This question is running through the contemporary American report Project 2061 (American Association for the Advancement of Science, 2000) the editors of which propose the re-establishment of the goals of education, concerning the learning result in sciences, so as to be absolutely compatible (to coincide) with those concerning scientific and technological literacy. The basic idea of Project 2061 is that a scientifically literate person is that which perceives sciences, mathematics and technology as interlinked human activities with power and restrictions, understands meanings and principles of sciences, is familiar with the natural world recognizing its unity and its variety, and uses scientific knowledge and scientific ways of thinking for personal and social purposes. By reading the program, the careful observer can discover positive and negative sides, which it would be pointless to refer to in this article, but they can be found in the bibliography (Tselfes, 2001). It is also especially useful to keep the editors' proposition in mind and look further into the scientific contents which the program offers, at least as far as they concern sciences.

From the above, it is obvious that the basic principle in choosing scientific contents to be taught is determined by the thought that there are some points essential for scientific literacy which school should teach and as effectively as possible instead of exhausting itself in ever increasing scientific topics in a hopeless attempt to teach everything about the total of cognitive objects. This scientific content is articulated (Project 2061) chiefly in the units:

- The nature of sciences, mathematics, and technology as human achievements
- Basic knowledge about the world as they are presented by science and formulated by technology.
- What people should understand from the history of scientific discoveries.
- Values and attitudes of intellect essential for scientific literacy.

Nevertheless, a curriculum could be assembled based on the specific scientific contents in the area of Sciences, especially Physics? It is obvious that if we want education to be offered and not merely instruction, the required curriculum should:

- lead pupils- and people in general- towards a critical and simultaneously inventive mind (Kettering 1994),
- to ensure the realization of their conditionally existing talents (Schack 1993) and
- to help young pupils to keep the cleverness and devisability/creativity of their childhood after school and during adulthood,

when researching or dealing with matters regarding Sciences and their applications, an area in which traditional school education seems to have failed. So, before proceeding to specific propositions whose application relinquishes such characteristics in a curriculum, we will attempt to understand the term creativity a bit better as it seems to play a determining part accompanying critical ability as much in a researchers work as well as a requirement for the intellectual development of the young pupil and the trainee in general.

Creativity

According to Guilford, the intellectual properties of human beings can be classified in three ways: according to the basic functions/activities of intellect:

Mnemonic, Cognitive, Converging and Diverging Thinking

I. based on the contents on which the previous activities act: shapes, symbols, meanings and attitudes

II. based on the results of the action of the above intellectual functions: units/chapters, classes, relationships, transformations and consequences.

From the combination of functions, contents and action on the content 120 intellectual abilities arise, as long as the elements of the combinations are regarded as independent of each other. Guilford and his associates primarily collected their study and gave special attention to two of the five intellectual functions the converging and diverging thinking. Converging thinking concerns intellectual processing of data, information, and material which has been acquired and memorized in a quest for rational sequence which can be characterized as the solution or the conclusion. Analysis, classification, data comparison of a specific problem with existing logical structures – models belong to the area of converging thought and that is why it is also known as critical thinking. Diverging thinking on the other hand has the same starting point, data processing, but is aimed at the quest and discovery of all the possible solutions and answers, redefining, recreating and generally producing the appropriate combinations. At this point it is acknowledged that diverging intellectual procedure is the twin of creative thinking. Although research attempts for the deeper understanding of human intelligence began with a division between the two types of thought (Xanthakou, 1998) which reflected their differentiation in meaning, contemporary research reality indicates that while building the model of the problem and the consequential route of the solution both intellectual procedure partake in the process and furthermore their degree of correlation is defined by the mental difficulty and originality of the problem leading to the genius solution.

Man's daily survival demands his interaction with the environment, natural and social, in which he lives and acts. As a result of this interaction, some people are in a position to discern problems, to realize the difficulties, to record unusual situations, to be impressed or/and worried by the existence of cognitive insufficiencies, when looking for explanations not necessarily of a regular type and often unusual and personal. This ability is characterized as sensitivity towards environmental problems and according to Guilford it is related to the understanding of meaning sequences. And as the problem, which produced, the incentive exists and functions, a large number of ideas and possible solutions or answers, too, are produced from the creatively thinking man either directly or after a certain length of time[4]. And it is the richness of the total production which grades and characterizes one's intellectual ease (of words, ideas, coherence, expression). But how can all this production arise? Certainly, not through the routine way. On the contrary, divergence from the usual intellectual routes or/and revision/alteration of the way of thinking is demanded for approaching the problems with change in meanings, uses, contents for understanding, and strategies for adoption. This situation characterizes intellectual functioning as flexible and one criterion is the possibility one has to change answer categories or even better the possibility one has for diverging production of semantic classes – categories (Xanthakou, 1998). The next question set refers to the originality of thought, which is materialized through productive process. The "work" which arises thus is judged as rare or/and unique compared to an appropriate prototype model although in many cases work is produced for which we do not have object classifications to compare them with and to classify them. Furthermore, bearing in mind the adaptation of production to reality we avoid involvement with work-products of ignorance, which are mistaken or/and may be carrying pathological situations. Finally, for the interaction of human beings and their natural or social environment to be correct, there is the need or presumption of abilities of synthesis, transformation and generally processing. Synthesis corresponds to organizing ideas in wider "shapes" judging by the increase of content and presuming active discovery of combinations of comprising parts and not just their blending (Xanthakou, 1998). Synthesis of ideas and their analysis in order to gain new syntheses comprise combinational activities of a creative nature (Gowan, Demos, & Torrance, 1967, p 19), where new sets, relationships and models of experiences as regarding to conception arise (Arnold in Gowan). New correlations and views are discovered in the old specific functioning objects of the environment (Kubie in Gowan). But what do you do with a well-organized set? It seems as if one of the possibilities of creative man is the redistribution or/and the re-establishment of such a set. We are thus speaking about alteration of objects as to their form, function or use with the ultimate goal of performing "work" which is new in relationship to what it was planned to perform. We are also speaking about the alteration of "shape" with an originally set content through functional comparisons, so as to have multifunctionality arising (Inhelder & Cellerier, 1992). All the aforementioned demand and require idea processing abilities. Concerning processing, it means the analysis, improvement, integration and finally the presentation of an idea which is simultaneously both attractive and liable. Summing up, we could insist that creative thought is defined by (Xanthakou 1998):

- One's tendency to be a sensitive problem tracker in the environment he constantly works
- One's ability to be open to information or experiences which flow from his interaction with his natural or social environment
- One's possibilities to express many different ideas and hypotheses for the problematic situations one faces
- One's ability to combine, transform, process existing contents in order to produce new original and appropriate "works" – products.

Further research in the area of understanding diverging and converging thinking, has shown that creativity[5] (Xanthakou 1998):

- Comprises a mental phenomenon with a catholic and worldwide character existing qualitatively but differentiated quantitatively as to the total of mankind.
- Derives from humans' tendency to spring into action altering and adapting himself to time-space in a constant dialectic relationship with his environment.
- Is closely connected to man's social and cultural environment, so that under positive cultivation conditions humans' inherent tendency appears and transforms to chronologically continuous functioning ability
- Results in behaviors, which derive from and correlate with the special characteristics of the creative person's personality.
- Is defined from both external/environmental factors as well as internal intellectual processing, the resultant of which follows a set course, resulting in the production of "work"-product (mental or material).

Furthermore, this work is new as to the logic, acceptable due to appropriateness and usefulness, satisfying the sensible criteria of individuals, groups or societies, within which it was produced at the precise moment but there are not rarely cases where the work itself imposes the new logic criteria.

We integrate, at this point, with the recognition of the fact that although creativity seems to be connected to diverging – creative thinking, the solution to the problems demands productive type thinking with the converging, diverging and intellectual function being present processing wide sets of data cooperating with memory and perception (Xanthakou & Kaila 2002). What can one say about someone who pinpoints and solves problems creating new knowledge? Could a system possibly be approached as a system evolving in an environment, which is changing or rather evolving in time[6] (Wallace & Gruber 1989)? Is a person who asks new questions, solves problems producing innovating products which lead to gaining social acceptance within the work frame of the solver (Gardner 1993)?

None of the goals set by the solver and more generally the thinking human could be obtained without the help of a rational mind (Haslam & Baron 1994, Ford 1994). An intelligence which according to the "information processing" theory (Koliadis, 2002) can be made perceptible more from a qualitative than a quantitative point of view and the basic characteristics of which can be described with emphasis more on intellectual procedures and less in countable results (Flouris 1995 p. 244). Compatible to the previous theory is the "multiple intelligence" theory which was formulated by Gardner (1983, 1993). According to this theory seven independent types of intelligence, music, kinaesthetics, logicomathematics, linguistics, spatial, inter-intrapersonal, begin their life along with the subject of intellectual procedures primarily in rough form evolving and expressed in every phase of its life defining, by its degree of activation, its productive process. Although the part played by feelings during the solution of problems has not been studied sufficiently, former studies have discovered non-cognitive factors, attitudes feelings processes of a premature testing which hinder the activation and involvement of children in situations-problems (Philippou & Christou 2001).

The educational experiment

Wishing to explore how far it is possible for both critical and creative thinking to make their presence simultaneously evident within the limits of educational activity in Science resulting in creative teaching and learning which are nor confronted as panaceas or miracular tools but as means of logical expression, understanding, and improvement of the same learning process as it is expressed through problem solving, (Torrance & Myers 1974, Torrance 1994, Treffinger & Nasab 1996) the educational experiment described in this unit was planned and conducted. The goal was to look into the reactions of elementary and pre-school teachers who voluntarily attended a twenty-hour program, when a normal in service training in matters of experimental teaching of sciences changed context, transforming from traditional type to creative problem solving. Our decision to attempt such an alteration is based mainly on two arguments. The first being that a creative solution problem constitutes a systematic approach (Treffinger, Isaksen 1996 in Joyce, Isaksen et. al. p. 120 –123) which can be placed within the creative learning model (Treffinger 1979, ref. in Joyce et.al. p. 120, Xanthakou & Kaila 2002, p. 133-136, Chionidou-Moskofoglou 1999). According to the second argument, the ability to solve problems both within the limits of a science exercise as well as problems of daily life add to the pupil's, the student's and the teacher's dexterities which characterize scientific and technological literacy (Kokotas, 1997, p 101)

In order to materialize the project for the problem, answers to the following questions had to be found:

- How can we convert usual experimental processes into creative type problem situations?
- How can we convert traditional teaching into a teaching, which utilizes creative solution problems?
- Is such a conversion useful, does it express real needs and does it improve the educational process?

The first phase of the program began with a discussion regarding the manners with which through observation information can be gathered. The way different stimuli optical, acoustical, of touch, etc. are recorded and their combinations were analyzed through many examples and use of the appropriate optic acoustical means and visual aids, an attempt being for awareness of the participants and to improve their ability to observe, and also to distinguish situations, where observation is a problem and the senses inadequate for observation.

During the second phase, traditional laboratory material as well as daily materials were selected[7] in such a manner so as to be able to lead to the appropriate conditions for experiments and presentation in physics. All these materials were laid on a long table, which enabled all the trainees to have access to it, without been organized or placed in any certain manner. On the contrary, during the whole process any choice, placement or grouping conducted by the participants would be acceptable. After their division into groups[8], the participants were asked to "play" with the material, doing with it anything that they believed would have meaning or was feasible.

The first trainer's intervention took place in the beginning by asking the members of the groups to handle and investigate all the available material and by indicating them to discuss the various ideas, which would arise deciding on what they finally wanted to materialize. The goal of this intervention was double. Co-effect with the material and with the participants among themselves.

After the first surprise of the participants which arose from the fact that they believed in the need to use the material under "specific laboratorial ways" which they "had not been taught" and "therefore need not know as they were elementary and pre-school teachers" and "they none of them had laboratories" and the getting over of their fear that the specific materials "bite, wound, hurt" or "are dangerous" the situation was completely reversed.

Fear and hesitation were originally replaced by a familiarization joyful and full of childlike liveliness – playing with all the materials and then the appearance of a large number of ideas and schemes about things that could be done. Everyone had activities, experiments and constructions to propose, everyone had an opinion, not necessarily coinciding with that of the one next to him. The production of ideas took on the form of an avalanche[9] there were attempts to criticize and test the ideas to discover what each group would materialize.

At this point there was a second intervention by the researchers asking the groups to try and materialize the idea they chose as appropriate and to their questions as to if something was correct or not, they answer was "try it". Intervention, to alter the scheme did not take place[10]. Slowly but steadily the groups reached their results. They started asking for information about what to do afterwards.

The new intervention of the researchers was to boost them into thinking, what in their opinion would make sense for them to do, continuing the process. Devices which were set up and propositions of the group are recorded in the following table:

At this point trainer's intervention was intended to facilitate each group to choose one of the activities they proposed and create a scheme for an experiment of measurement and to conduct it recording the data. That means they should find and construct a problem (Xanthakou & Kaila 2002 p. 121,124) and then to create an algorithm for the solution of the problem. The trainer acted as fellow-researcher-member of the group helping to set "the question" but also "to express the problem", a process which is often more irksome than its solution (Einstein & Infeld, 1938, p 83).

Devices	Propositions
1. Oscillated System – spring mass vertically hung	• To define the relationship between the length of the spring and the weight which is hung each time. • To hang different springs and hang the same weight on them. • To hang successively weights to discover if the spring will be damaged and with which weight.
2. Oscillated System – pendulum	• To find if the system will start oscillating and when it will stop. • To see, if the angle we deviate it is small, if it will stop at the same time span. • To do the above with different lengths and weights. • To find how long a oscillation lasts.
3. Device to boil water	• To measure what the thermometer indicates every moment • To put double the amount of water in the test tube and boil it again • To put aluminum foil over the tube while boiling • To measure how long it will take for the water to evaporate completely • To warm the rulers and see what happens, which will warm up quicker altogether.
4. Creation of different electric circuits	• To make different circuits with light bulbs and switches which will light in line • To measure the current • To check if, whatever else we connect along with the bulbs, the circuit will light up • To make a circuit with the fan working • To connect the dimmer coil, too, to see if the current runs through • To place the magnets to affect the current
5. Device to study optic phenomena	• To darken the room and change the direction of the torch light with the mirrors • To aim with the laser light • To analyze light through a prism • To make light.

The third phase began with the groups having chosen:

- To measure the spring's period and to study the factors on which it depends
- To find ways to distinguish how hard or soft a spring can be and when it stops being elastic.
- To measure the variation of temperature with time of the water, until it boils and a while after that.
- To measure the current of a complicated circuit
- To try and affect the magnetic needle with the dimmer coil, activating the circuit, which contains it.
- To use the laser-pointer, to study the ways of light spread

Originally each group conducted its own experiment presenting their results afterwards. After that, in circular order, all the groups conducted all the experiments. The general discussion which followed analyzed the problems and the differences which arose during the experimenting of the groups and had the opportunity of discussing both the accuracy of the measurements introducing the meaning of experimental error as well as the most productive presentation and processing of the measurements connecting them to the procedure which was adopted by the groups.

The fourth phase began with the school Physics textbooks[11] for the fifth and sixth grades of elementary school. Existing groups were asked to study activities and experiments which are conducted here mainly with simple means from the child's everyday environment. After the study, every member of the groups had to choose, to materialize, and to present three of them, mingling them with her/his own materials. A small report of two or three pages, at the most, had to accompany "the experiment" which functioned explaining which principle materializes its possible educational usefulness. But is the "experiment" had not been successful, it should be explained what according to the "experimenter" went wrong. This phase was successfully completed and prepared the last phase.

The fifth and last phase predicted the collecting of the group and after discussion and exchanging their experiences the common decision for every member of the group to undertake a construction which will materialize a principle of Physics or generally Sciences with the extra characteristic of being useful. The choice of sources, topic, materials, and the construction was the absolute disposal of its creator, as was her/his cooperation with the group members. Furthermore, an essay would have to accompany the construction, its function and the physical principles it materializes and its usefulness. All the members chose three alternative ideas and materialized one of them. The trainers posted questions, searched, cooperated and finally after about a month, radios, photographic-camera-boxes, logic gadgets, kaleidoscopes, hot-air balloons, electric doorbells, light ray houses, rockets, compasses, erupting volcanoes, and also indicators to distinguish acids from bases, crystals, water-filtering appliances, waterworks, magnetic fish and also soap-bubbles made their appearance surprising with their originality, their simplicity, and their functionality in the research group.

Essays describing the constructing methods and elements of theory from physics, which were gathered with hard work, completed the trial. The relationship with the research group was absolutely cooperative and the trainers' role only to facilitate, when all other sources had dried out.

Observations

We will refer to some observations which took place during the activity and which characterize it.

1. Acceptance of the activity arose, inhibitions and fears dissolved, initiative developed, there was cooperative (Cohen 1994, Chionidou-Moskofogkou 1999, Stavridou 2002) approach and as far as learning procedures are concerned they were interactive and creative.
2. Questions of the type "what could you make" with this material result in the activation of curiosity, prompt to research possibilities, they lead to the coexistence of knowledge in Science and fantasy and sometimes sense, and even paradox too.
3. Through indulgence, different opinions were being heard and the fear of rejection was overcome. Mistakes became arguments for repetition and improvement of thoughts and results.
4. It was observed that the attempt to achieve the goal beginning from an initiate confused set of laboratorial objects and materials of daily use led according to the researchers to the desired result, although rules of logic and physics regarding what could possibly be achieved were often "broken" during the phases, and especially during the phase of brainstorming ideas.

Conclusions

In this study we tried to face the in-service training in science from a different point of view, producing a project of creative solving in successive phases, each of which had well established goals aiming to study the reactions of elementary and preschool teachers who took part in the program voluntarily. After careful analysis we believe that:

It seems that when interest has been motivated from the appropriately expressed question creative process of in-service training arises in Science, which shows that it is not only the final result which counts but the process itself and the feelings it excites. (Heller, Monks et.al., 2000, p. 82, Chionidou-Moskofoglou, 1999). It has also been concluded that even if a situation-problem, such as the present, presents complication and causes uncertainty and fear at first, it is difficult and demands research, perhaps it is one of the most important tools which supply us with dexterities regarding Sciences and the handling of problems of the real world (Webster, 1995 ref. Meador 1997, p. 69). The ability to solve problems and mainly problems of everyday life is especially important, mainly when they are of the creative solution type. And perhaps they should comprise an essential element of the curricula for any level of education and every cognitive object especially those, which regard Science in general.

Epilogue

As an epilogue to this attempt, we cite some of the opinions of the participants about the program they participated in.

"It began as a game "let's play physics" and ended in us increasing our dexterities in the expression and solving of beautiful problems".

"We created objects which functioned and materialized principles of physics. We expressed beautiful problems increasing our knowledge".

"I like conducting experiments in physics, I learnt the process, but also experiments with simple means, now I'll make my own for school".

"We selected this seminar and we did all these things although they were difficult, because they are especially important".

"I search the net for experiments, there are so many sites, it's a pity that in their majority they are not in Greek language".

"I made a MW radio receiver and now I'm studying the theory on FM radios, I'll make one to listen to with my friends".

NOTES

1. As it is expressed through the sequence: observation, hypothesis, experimental laboratorial testing/research, analysis of experimental measurements, formulation of models with the use of mathematics, simulation of natural system with the aid of a computer etc.
2. According to Kalkani (2002) it is not the exact object or the research which defines physics or science, nor is it just the research methodology which is followed but also the deontology which accompanies it in the sense that the newly experimentally verified

theory must be adopted and taught until it too is replaced by another in its turn. That means that the rejection of all the previous inefficient or theories which can experimentally be proven as false is supported here, a situation which discriminates this from other cognitive fields.

3. Abilities such as deductive generalization of theories, which had been scientifically proved as correct, foretelling of the evolution of natural procedures which results as a conclusion of analysis of a model of the system, agreement between theoretical and experimental data, but also the fertile confirmation of their opposition which leads to dialectic synthesis and new valid knowledge as well as researching attempts are the characteristics of the essentially scientifically independent critical-evaluating and creative thought (Verganelakis, 1985).
4. By this term we mean the preset time "t" within which there is response of production of ideas as well as possible solutions to the stimulus which the problem poses.
5. At this point, we should notice that creativity comprises a multiple phenomenon. Thus, the functions of production arising from the creative factor of intellectual procedures of the human intellect are not the only ones contributing to the creative production of the thinking subject (Guilford ref. to Xanthakou 1998, p. 39).
6. We have a systemic approach to the phenomenon, where the individual is involved as intellectual structure, personality, value and ideology system, as a process of thought and action.
7. So that they could be the simplest possible which could be used, without danger for the participants arising (eg. Boiling with candles, electricity provision from batteries, etc)
8. Every group had five members and twenty elementary teachers participated in one and pre-school teachers in the other.
9. Phase of idea production through the technique of brainstorming (Xanthakou & Kaila 2002, p. 124).
10. Eg. To the proposition that we can tie a weight on a spring and by keeping one end steady to rotate it studying the circular movement, no redirection of the thought was attempted nor was the activity forbidden, but observation of the activity so as to avoid an accident.
11. Apostolakis E., Korozi V., Panagopoulou E., Petrea K., Savvas S., (2002). *I research and discover*. 5th grade elementary school. Athens, Ministry of Education.

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