The impact of Nanotechnology and ICT integrated Science Education on Female Vocational High School Learners

By

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ABSTRACT

The research and data available in the fields of science and technology all show that young people, in particular girls display a negative attitude towards science based subjects at school and that they have slight tendencies to plan a career in these fields despite all the significant developments in science and technology worldwide. And this is even more dramatic in our country as girls' negative attitude towards science based subjects impact their academic success and thus pose the threat of a society with such people who fail to acquire the skills required for the 21st century of the global world and who have closed themselves to innovation. This study also aims to impact attitudes of girls living in areas whose socio-economic standards are poor with limited opportunities, on international scale, towards science based school subjects in a positive way as well as boost their motivations on science learning. And through employing the Virtual Lab (www.ntse-nanotech.eu) at the web-site designed with a view to achieving this as well as the lesson plans entitled "Understanding Nanotechnology", "Nanocrystal Fabrication" and, "LEDs", which are inquiry-based lesson plans with reflections of Nano Technology in Science Education, courses in which students actively participated were given for three weeks. These courses, in other words activities , took place at 30 Ağustos Girls' Technical and Vocational School of Ümraniye District of İstanbul and 26 students (girls) aged 16-17 were in. A pre and post-tests method was implemented through the use of a survey measuring the students' attitude towards science and whose validity and reliability were proven. As for the determination of their academic progress, the "end of class rubrics" existing in the Virtual Lab were used at the end of courses.

The outcomes were analysed using SPSS whereas their before and after class attitudes together with their academic progresses were determined depending on the frequency and

percentages of their answers to the survey questions. It was observed that the girls attending the ICT Department of this vocational school developed a positive attitude towards science based school subjects.

Key Words: *ICT learning, inquiry based, science education, motivation, attitudes, single-sex classes, nanotechnology*

INTRODUCTION

In many international reports on education, the potential shortage of human resources in key scientific professions was identified and they recommend urgently modernizing science teaching in schools. The EU member states have set a benchmark to reduce the proportion of 15-year-olds with low achievement in science to less than 15 % by 2020[1]. To be able to achieve the benchmark target by 2020, there are many obstacles and problem areas are identified in school education. At the same time, it is frequently questioned that it is possible to raise the motivation of pupils, to increase their interest in science, and at the same time, to increase attainment levels. Is it possible to achieve the successful science education in schools in reaching all pupils as well as educating future scientists?

According to E.G. Rocard Report (2007) there is 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. Reluctance of the students to learn science, rote learning and traditional teaching approaches and the lack of supportive and powerful educational materials advancing science education can be shown as the main reasons. 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). Therefore, the education of science needs to be renovated and enhanced with the new science technology and computer technology (NTSE Concept Paper, 2010).

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[1] Council conclusions of 12 May 2009 on a strategic framework for European cooperation in education and training ('ET 2020'). OJ C 119, 28.5.2009.

In the EU-27 in 2009, according to the PISA results, students in Bulgaria, Romania and Turkey had considerably lower average achievement than their counterparts in all other participating Eurydice countries. The mean scores in these countries were about 50-70 points lower than the EU-27 average. These countries also had the lowest results in 2006 and the proportion of students lacking basic skills in science was especially high in Bulgaria, Romania and Turkey – about 40 % of students in those countries did not reach the proficiency Level 2.

National and international indicators show that there is a big inadequacy in science and technology education in Turkey as compared to other countries. This important problem affects the young students' structure of thinking perspective and perceptions of nature in a wrong way. The main problems with science and technology education are insufficient number of science and technology teachers' taking active role in the preparation of the programs, the insufficient in-service training of the science teacher in the transition state of a new program, the huge numbers of the students in the class, the informational education orienting students towards only exam achievement, the broken link with other lessons (e.g. mathematics program) and insufficient physical conditions of schools (less laboratory opportunities) (Ozden, 2007).

When looked from a gender perspective the problem is even worse as, in general, girls are less interested in science education than boys. Of the attitudes measured in PISA, the largest gender difference was observed in students' self concept in science. On average, girls had lower levels of belief in their scientific abilities than boys in all European countries. Boys also had higher level of confidence in tackling specific scientific tasks. In most other aspects of self-reported attitudes towards science there were no consistent gender differences. Both boys and girls had similar levels of interest in science and there was no overall difference in boys' and girls' inclination to use science in future studies or jobs (EACEA/Eurydice, 2010; OECD, 2007b). Approximately 60% of higher education graduates in the fields of science, mathematics and computing are men. How can this gender imbalance be improved? These are some of the issues addressed in this study. During the study we will question ***"Does a Nanotechnology and ICT integrated Science Education make a significant difference in the adoption of a positive attitude by Students of Girls Vocational Schools towards Science***

Education?"

This study aims to identify the attitudes of girls living in areas whose socio-economic standards are poor with limited opportunities, on international scale, towards science based school subjects and to boost their motivations on science learning embedding the ICT and nanotechnology through employing the Virtual Lab (www.ntse-nanotech.eu) experiments of NTSE Project[2]. In this study, the lesson plans entitled "Understanding Nanotechnology", "Nanocrystal Fabrication" and, "LEDs", which are inquiry-based lesson plans with reflections of Nano Technology in Science Education, courses in which students actively participated were given for three weeks.

In our classroom implementations, the ICT tools mostly the educational materials (Lesson plans, simulations and videos) of NTSE Virtual Laboratory will be used. Nowadays, virtual learning environments represent important technological resources that help the learners (but also the teachers and trainers) to introduce and demonstrate science concepts, to acquire knowledge, and to perform experimentation without risks. Thus, a virtual lab "enables the learner to link between the theoretical aspect and the practical one, without papers and pens, being electronically programmed in computer, in order to simulate the real experiments inside the real laboratories." (Harry & Edward, 2005).

METHOD

In the study, pre test-post test design of the experimental models has been employed.

Data Gathering Tools

In the study, pre and post tests including 5 questions to define their awareness, motivation and perceptions towards science education and the place of ICT and nanotechnology in their life. Apart from this, the student's grids were performed to define the level of their learning and the reflections were used to understand their motivations and challenges in science education integrated with ICT tools and nanotechnology topics.

Work Group

This study took place at 30 Ağustos Girls' Technical and Vocational School of Ümraniye District of İstanFbul and 26 students (girls) aged 16-17 in 11th grade IT department students

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[2] NTSE Project is LLP Transversal Programme KA3-ICT Project with reference number: 511787-LLP-1-2010-1-TR-KA3-KA3MP

during the 1st period of 2013-2014 Academic Year.

STEPS OF THE PROCESS

The study was carried out according to the steps below:

1. The research was initiated in Vocational school and the 11th grade class with 26 females was selected to implement the NTSE virtual laboratory experiments.
2. The course teacher (ICT subject) worked collaboratively with the NTSE project experts while implementing the virtual laboratory activities.
3. Before the classroom implementation the pre-test was conducted with 26 females to understand their motivation and awareness on science and Nano technology education.
4. The project experts presented the NTSE Virtual Laboratory and project procedure.

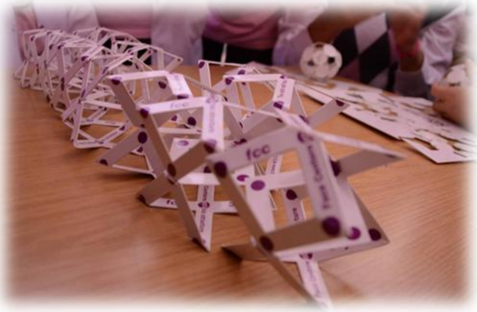
5. Three lesson plans and experiments were chosen (Understanding Nanoscale, Nanocrystal Fabrication, and LEDs) from the NTSE Virtual Laboratory according to their level and interests.
6. Each experiment was conducted in two hours of lesson. The steps of the lesson were detailed in empiric procedure.
7. End of the experiments the students grids were conducted to check what they learnt and remember.

8. After three-week classroom implementation, the post-test was conducted to the students to check what they learnt.
9. The results were gathered and analyzed.

EMPIRIC PROCEDURE

Empiric procedure is explained in a timely fashion below.

1. While planning the education, integration of inquiry based learning, improving digital and science literacy drawn out in scope of the NTSE project have been taken into consideration and each activity aims to gain these competences.
2. The week before the commencement of the implementation of the empiric process, the project expert has met the test group students and informed them on the implementation and tried to motivate them to willingly participate.
3. Before the implementation of the experiments, the access to the virtual laboratory and the sections were introduced.
4. Two hours of lesson were dedicated for virtual and hands on activities.
5. Each activity was done in groups of 3 or 5 to engage the students into active learning process.
6. The virtual laboratory implementations were conducted through following the steps of the teacher guide of the Nanocrystal Fabrication experiment integrating the steps of Inquiry Based Learning as in the following;
    - First teachers played the video about the “ Nanocrystal Fabrication” in movie section,
    - Before opening the simulation about the “solution”, the teacher prepares a solution of hot water and sugar to recall their previous knowledge about the solubility, solutions and dissolution. The teacher provides monitoring of the process of the formation of nanocrystals.
    - Later visited the simulations and played them in the order of the four simulations (dissolution, molecular dissolution, precipitation, molecular precipitation) in interaction section.
    - Fcc, hcp ve buckyballs model were made by students to investigate the structure of fcc, hcp (types of crystal unit cell structures) and buckyball molecules for deeper understanding of structure of solids and nanotechnological products.



- Top-down and bottom up approaches were instructed through using the play doughs to let them discover what nano technology and understanding creating the products in suitable chemical and physical features through using different approaches.

7. During the implementation, some modifications and extra activities were inserted in LEDs experiment according the needs of the vocational school learners such as the activities and experiments on processing of semi-conductors and transistors.

8. End of the each experiment, the students reflections were gathered to learn their likes, dislikes, challenges and motivations in their new learning. Sometimes structured feedback was conducted orally to let the students share their strategies in their learning experiences.

FINDINGS AND COMMENTS

Table 1.

The pre-test and post-test frequency values regarding the question: ***"How interested would you be to learn the below-mentioned science topics in your science classes?"***

	1st Quest	**2nd Quest**	**1st Quest**	**2nd Quest**	**1st Quest**	**2nd Quest**
	Very interested	**Very interested**	**Interested**	**Interested**	**Not at all**	**Not at all**
Chemicals, their properties and how they react	1	5	18	17	7	4
Atom, molecules and chemical bonding	2	2	4	12	20	12
The nature of sound and its properties	4	7	11	19	11	0
Robots and automated machines and their use in life	5	10	11	10	10	5
Electricity and its properties	5	9	11	9	10	8
The structure on Earth and other planets	4	4	4	10	18	12
Renewable energy and new energy sources.	4	7	9	12	13	6
The use of lasers	7	9	10	11	9	6
How radios and TVs work	11	9	8	13	7	4
Why we can see the rainbow	11	11	11	11	4	4
How energy can be saved or used in a more effective way	9	12	11	9	6	4
Technology in healthcare and medicine	5	12	12	14	9	0
Latest inventions and discoveries in science	13	6	8	16	5	4
Nanotechnology and its' use in life	7	7	9	16	10	3

According to Table 1, significant differences stand out between the answers students have given before and after the application. Following the application, the differences in student answers have appeared especially in the topics of the use of technology in healthcare and medicine, Nano technology and its use in daily life, and these are in favour of the post-test values. These results show that the conducted applications motivate student interest in the areas of science and technology.

Table 2.

The pre-test and post-test frequency values regarding the question: ***"What do you think about the science education at school?"***

	1st Quest	2nd Quest	1st Quest	2nd Quest	1st Quest	2nd Quest	1st Quest	2nd Quest
	Yes	**Yes**	**Not Sure**	**Not Sure**	**No**	**No**	**Missing**	**Missing**
School science is a difficult subject	5	9	10	10	10	6	1	1
School science has opened my eyes to new careers and new events around me	7	8	12	14	4	3	3	1
I like school science more than most other subjects	5	6	7	11	11	8	3	1
The things that I learn in science at school will be helpful in my everyday life	9	8	13	11	1	6	3	1
School science has increased my curiosity about things we cannot yet explain	7	5	11	15	5	5	3	1
School science has increased my appreciation of nature	10	18	12	6	2	2	2	0
School science is my way to technology and science knowledge	7	15	9	10	8	1	2	0
TOTAL	50	69	74	77	41	31	17	5

According to Table 2F, the only significant difference between student answers before and after the application appeared in the items "Science classes at school improved my respect for nature" / Science classes at school are topics that direct me towards technology and science". Before and after the application around 50% of the students answered some of the questions as **"not sure".** These result shows that the applications conducted did not have a significant effect on their attitudes and opinions about the science classes at school.

Table 3.

The pre-test and post-test frequency values regarding the question: ***"according to me, the best ways to learn more on science and technology"***

	1st Quest	2nd Quest
In-class lecture	9	16
Reading textbooks	5	7
Watching clips and documentaries	17	14
Laboratory and experiment simulations	23	16
Real experiments	24	20
Guided walks in nature	13	12

According to Table 3, the only significant difference between student answers before and after the application appeared in the item "In-class lecture". According to the post-test\ 16 students stated that the best way to learn in science and technology is to have lectures in the classroom. On the other hand, 7 students showed an attitude change in the post-test with the item Reading textbooks. The other items are in favour of the pre-test.

Table 4.

The pre-test and post-test frequency values regarding the question: ***"Would you prefer learning facts on scientific topics on the computer and on the Internet?"***

1st Quest	**2nd Quest**	**1st Quest**	**2nd Quest**
YES	**YES**	**NO**	**NO**
21	17	4	9

According to Table 4, the answers to the question "*Would you prefer learning facts on scientific topics on the computer and on the Internet?" have resulted in favour of the pre application test. While 21 students have said yes before the application, only 17 said yes after.*

Table 5.

If your answer is "Yes" please define which devices you would prefer to use:

	1st Quest	2nd Quest
Power Point presentations	5	3
Images	4	6

Video Clips	15	5
Virtual experiments	7	9

According to Table 5, the students who evaluated the Video Clips as the learning tool they use before the application (f: 15) have included the Virtual Experiments (f: 9) as another learning tool after the application.

Table 6.

The pre-test and post-test frequency values regarding the question: ***"Which virtual platforms would you prefer to use in order to get more information about scientific topics?"***

	1st Quest	**2nd Quest**
Only the virtual platforms made specifically for it	10	9
Social networks – For example facebook that includes science materials	5	8
Forum/Discussion groups that include science materials	9	8

According to Table 6, there is no meaningful and significant difference between the pre-application and post-application answers for the question *"Which virtual platforms would you prefer to use in order to get more information about scientific topics?"* While the item, Social networks – for example facebook that includes science materials, was selected by 5 students before the application, the number of students who selected this item went up to 8 after the application.

COMMENT

When the results are analysed, there is no significant change in the pre and post-test results in the female students' perception regarding whether the science classes are hard or easy. The reason has been determined to be the lack of science classes being offered in their school. In order to change the perception of these students towards science education, a long-term practice will be necessary.

In the item **2b "School science has opened my eyes to new careers and new events around me",** the topics they encountered during the 3 weeks they spend between the pre-test and post-test seem to have caused a doubt that led them to question their background. Since these students haven't seen sustainability in the science learning processes, they seem to not make any future plans.

In the item **2c "I like school science classes more than most classes at school"** have confused 3 students, and created a positive attitude change in 3 other students. In order to reach more students, it is considered that this 3-week process may not be enough, and that they can generate positive attitude with a sustainable science education.

When we look at the item **2d "The things that I learn in science at school will be helpful in my everyday life"** the fact that students are struggling to see an overlap of nanotechnology with their real lives, stands out. These students that study in the computer department of the Girls Vocational High School were able to draw parallels between their areas and only one of the three applications we have explain, that is the ***Led.*** The main reason for this, as defined before, is their struggle in the applications due to lack of their background in science education, and that they are not attracted to the other two topics, other than the "LED" topic.

For **2e** "School science has increased my curiosity about things we cannot yet explain." item, we can say that students are a little bit more confused, and the doubts and biases they had seem to have increased. Coming from a quite insufficient science education process, these students might be hesitant towards this question due to lack of science classes in their school.

When we look at the item **2g "School science is my way to technology and science knowledge",** we observe a positive attitude change in several students. These three-week experimental ICT-based learning processes that they see as nanotechnology-based seem to make more sense to the students when it overlaps with their area knowledge. Also, teachers may influence student beliefs about the value of ICTs through their pedagogical practices. Research has shown that teachers can enhance student motivation for learning using challenging and authentic tasks that provide opportunities for exploration and collaboration are connected to the real-world, and appeal to student interests (Blumenfeld et al., 1991; Bransford, Brown, & Cocking, 2000; Schunk, Pintrich, & Meece, 2007).

Following applications, several students expressed their expectations for the continuation of the process, and some of them even wanted to develop various projects. The alienation of girls at the vocational high school from the science education and their insufficient background increases their doubts and worries regarding whether they will be able to find a place for themselves even in their own area of Information Technologies. It is very important to encourage female students via such projects.

Students’ answers to these items show how detached they are from learning by living or methods of learning on your own, that they expect the teaching methods they have encountered in this process of 3 weeks from all teachers, and that they prefer a process that is completely teacher-oriented. This attitude is not compatible with the skills of 21st century, and it goes against the constructivist education methods that the Ministry of Education tries to implement in the curriculum, and the MEGEP system. It is possible that this attitude of female students is a product of their insufficiency in their skills for learning on their own, and their lack of background. However, studies in various countries (Clarke & Teague, 1996 in Australia; Goode, Estrella, & Margolis, 2006 in the US; Kordaki, 2001 in Greece) indicate that information science instruction tends to be teacher-centered and to focus on the development of decontextualized technical skills, providing students with few opportunities for collaboration and engagement in challenging, creative, and personally meaningful tasks. This approach may have differential effects on boys and girls’ motivation because boys and girls are attracted to different aspects of ICTs and differ in their instructional preferences. Boys tend to be interested in the technical aspects of computing more than girls (Brunner, Bennett, & Honey, 1998) and prefer discovering things and solving computer problems on their own (Ching, Kafai, & Marshall, 2000). Girls, on the other hand, are interested in the creative aspects and real-life applications of technology (Brunner et al., 1998; Lynn, Raphael, Olefsky, & Bachen, 2003), and prefer instructional formats that enable them to collaborate and to share what they learn (Ching et al., 2000; Clegg et al., 2000; Volman, van Eck, Heemskerk, & Kuiper, 2005). Therefore, in order to remove the students’ teacher-focused learning habits and their perception that they would not be able to understand topics of science on their own, the students have to be included in creative and attractive projects, which will contribute significantly to the sustainability and effectiveness of learning.

When we look at these items, we can say that structured learning processes supported by up-to-date education technologies replace the students' preferences for classic tools. It is clear how students of the 21st century are living together with social media and the Internet, and therefore it is beneficial to utilize these tools in terms of grabbing attention, raising awareness and interest, and creating competition.

Throughout the experimental applications process that we conducted within the context of this three-week "The ICT supported reflections of Nano Technology on the science education" project, the basic problems we have observed in the 30 Agustos Girls Technical and Vocational High School include the fact that these students became distant from science education, that the career choices expected of female students are in totally different areas, such as child development, textile, health services, etc., that they are suppressed and directed by families and the society, as well as the effects of social-economic conditions.

There is considerable research showing that boys and girls differ in their ability and value beliefs for academic domains that are traditionally gender-typed as ''male" or ''female", in patterns that are consistent with gender norms and stereotypes (Meece, Glienke, & Burg, 2006). In particular, research on ICT learning shows that girls tend to have less positive beliefs about the value of ICT and their own ICT skills compared to boys (Volman & van Eck, 2001; Whitley, 1997). Boys' and girls' motivational beliefs are shaped by their experiences and may follow different developmental paths as a result of gendered socialization processes (Eccles, 1994; Meece et al., 2006).

Suggestions

When we analyze the data retrieved as a result of this study, our suggestions for the practitioner teachers and researchers are as follows;

1. This study examines the effects of educational materials (experiments, students and teachers guidelines and simulations) in the NTSE Virtual Lab only on female students. Looking at and comparing the effects on both genders (female and male students) in another study would bring in more data.
2. It is observed that the 3-week application process was not sufficient due to focusing on whether the materials and project applications used during the work process had generated a positive attitude in students about learning science. In the next study, it

will be beneficial to conduct more long-term applications for retrieving more data and observing attitude change.

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