TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 1, Sayı 2, Aralık 2004

Journal of
TURKISH SCIENCE EDUCATION
Volume 1, Issue 2, December 2004

http://www.tused.org

The Use of Information Communication Technologies in Primary Science Education: A New Teaching and Learning Approach

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ABSTRACT

The compulsory education is where children gain basic skills and habits. It is assumed that the knowledge, skills and attitudes acquired at this age contribute a lot to the success of individuals at their future. TIMSS (Third International Mathematics and Science Studies) report in 1999 shows that Turkey ranks in the last rows among 38 countries in achievement of children in their science courses. In response to this, Turkish Ministry of Education is investing a lot of money on technology in primary and secondary schools. But, there is not enough study on how the curriculum and teaching and learning should be modified to make effective use of the new technology. In this respect, our project aims at designing an educational model for science education that deploys active learning concepts in school and home environments and assesses the effects of the model on the learning of the children. To achieve this, a science topic was selected for 6th graders and some microworlds were either developed or downloaded from the Internet. All the materials were uploaded on the course web page. E-mailing was used as a medium of interaction. For three weeks, ICT-based and traditional education was practiced with both the experimental and the control groups. It was found that ICT based science education has a positive impact on the learning of children. It was also observed that children in the experimental group are more willing to participate in the class discussion.

Anahtar Kelimeler: ICT Based Education, Electricity, Primary Education, Internet

INTRODUCTION

The recent developments of the worldwide web, digital satellite technology, and new applications of virtual reality to build simulated learning environments are predicted to have particularly dramatic effects upon learning environments at all levels (Moore, 1973). The pace of growing demand for learning is far ahead of the pace of increase in resources. This conflict is challenged through the accelerating advances in digital communications and learning technologies. The collage that results as the combination of demand, limitations in resources (money, time, man-power, buildings, etc.), effective application of the content and new technologies is leading educators to seek for new models in education that meet the new conditions and take advantage of the new technology. These models are emerging and demand experimentation of structure, form, and process (Moore, 1973). Anderson (2002) summarizes an initial, preliminary portrayal of the approaches and findings drawn from selected countries and stated in the Second International Technology in Education Study (SITES). Some research findings are discussed here. Ainley and associates (*qouted in* Anderson, 2002) studied the ICT-based training processes within three dimensions: (1) taxonomy of the type of ICT resource used; (2) the complexity of the knowledge sought for the student outcomes; and (3) the complexity of the cognitive processing required by the student activities. Their study is related to individuals who design or analyze students' learning assessments using ICT tools. Their approach depicts analytical categories which may clarify the demands or expectations in terms of the higher levels of knowledge by which ICT-based instructional innovations are oriented.

Nancy Law and associates (*qouted in* Anderson, 2002) connected learning gains with the following assets of learning activities: (1) extended learning tasks; (2) personal meaning and relevance of the learning tasks; (3) availability of suitable facilitation. Their research proves that the most significant outcome of innovative learning activities involving ICT was empowerment, particularly of students.

According to the research of Sue Haris and associates (*qouted in* Anderson, 2002), the case studies were taken into consideration from two different points where ICT was accepted as the most important force in the redefinition of the classroom: (1) changing interactions within the classroom as a direct or indirect result of using ICT to support teaching and learning; and (2) the involvement of others (non-teachers) outside the physical classroom in students' learning activities. As an example, Sue Haris and associates understood that how the innovative practices led to a greater emphasis upon students who take responsibility for their own progress, including self-imposed deadlines, and in other ways improving their study and work skills. They also proved that evidence that the innovations fostered students' ongoing reflection about their own work.

In Turkey, Ministry of Education is carrying out basic studies which are directed to information and communication technologies in public schools in Turkey (Ministry of Education, 2004). However, studies on integrating ICT in National Curriculum cannot be accepted as sufficient. Because, the number of the studies on effectiveness of ICT in education is very limited.

In this paper, we propose a learning model that uses ICT in order to "expand" and "extend" both the teaching and learning processes for science lessons in compulsory education. Teaching and learning are expanded in the sense that active learning ingredients are included in classroom teaching through the use of computer *microworlds*. Teaching and learning are also extended beyond the walls of the classroom and time limitations through the Internet. Technology is used within instruction in the form of computer simulations, and at home as a means of interaction and self study.

THE TURKISH CONTEXT

In Turkey, Ministry of Education aims at achieving a fast development in the areas of information and communication technologies which are of economical and social importance. In this sense, preparations are made for spreading basic computer training and computer-assisted education. Within this framework; a total of 221,000 teachers have been trained in the use of computers, and primary education inspectors have had an intense in-service training, using the credit received from the World Bank. 3.188 information technology classrooms have been built in 2,802 schools, and tenders have been opened to build the same classrooms and to obtain software in 3,000 more primary schools. At present, 117,250 computers are being used for education in the primary and secondary schools. This figure does not include the computers obtained by means of donations, campaigns, schools societies, school-family associations, and alike (Ministry of Education, 2004).

Distance education services are being given through 'open basic education school', 'open secondary school education' and 'open vocational and technical school education' to provide equality of educational opportunities for every citizen and to support the primary and secondary education. 715,510 students are making use of such services. (Ministry of Education, 2004).

In Turkey, primary school students have difficulty in learning science. This claim is supported by the outcomes given in the Third International Mathematics and Science Studies (TIMSS) reports in 1999. In this study, Turkey was positioned in the last rows. There are lots of reasons for this failure. Some of the major reasons are related to: school environment, and curriculum. These are explained below.

The number of students in the classes in Turkey is around 40. In some primary schools, this number increases to 50-55. In most of the primary schools, science laboratories cannot be used efficiently either because of the lack of equipment or the lack of sufficient time. In addition, this crowded classes prevents the teachers from applying different learning and teaching strategies. Courses are usually taught by the teacher's lecturing. In most of the private schools, the situation is enhanced by reducing the number of students (around 25-30) in classrooms and integrating technology into teaching (Ministry of Education, 2004).

Important changes in the curriculum took place in the year 2000 when the primary school science curriculum was brought up to date. The new primary school science curriculum was devised according to the constructivist approach. It also emphasizes communicating ideas with others in a civilized manner, by means of presenting the knowledge they have gained either orally or in writing. The program includes subjects related to the earth, space and the environment, in addition to the more traditional topics in physics, chemistry and biology. The subjects have been organized in a well balanced way according to the science branches and classes; and the level of the subjects has been determined in terms of the pupils' ages. In addition, the topics which involve lots of mathematical processes have been lessened and transferred into a format in which students can understand the science concepts better (Cavas, 2003).

Despite these improvements, the curriculum is still overloaded. At present, science courses are taught within three hours a week. In this period, it is not possible for the students to acquire all the concepts, to run experiments, to make some research, to make observations, and to do projects.

AIM

As a solution to the problems mentioned above the researchers propose a model to transfer the classroom learning activities to the student's home by exploiting technological advantage. Within this approach, our study aims at modifying the traditional concepts of teaching to minimize the consequences of the restrictions posed by curriculum and classroom conditions and maximize the opportunities delivered by the new technology.

Selection of the Topic

In this study, electricity was chosen as a topic. There are many reasons why the researchers chose this topic. First, electricity is regarded as being difficult topic to teach by many primary school science teachers. Second, it is hard for many students to understand this topic because of its abstract concepts. Third, most of the students have misconceptions about electricity (Gil-Perez & Carrascosa, 1990; Duit et al., 1985; Chambers & Andre 1997; Heller & Finley, 1992; Wang, 1991; Shepardson, 1994). Fourth, it also requires mathematical knowledge and skills (Cavas, 2002).

Pedagogical Issues

Our approach to pedagogical issues can be summarized in the following steps:

1. Identification of teaching and learning strategies;
2. Development of the course material that will fulfill the course objectives;
3. Implementation of teaching and learning strategies; and,
4. Modification of the model and course material based on the feedback from the students and results of the assessment tools.

Identification of Teaching and Learning Strategies:

After choosing the topic, the researcher discussed how this topic could be taught in the most effective way using the facilities provided in the schools and the ICT experiences of the teachers. The learning environment can be described as blended learning environment that involves traditional lecturing, computer based learning and distant learning. Pedagogical considerations are as follows:

- Discover the previous knowledge of the students.
- Discover the misconceptions and deal with them.
- Motivate peer-peer, student-teacher, and student-family learning.
- Motivate students for critical thinking.

In this respect, our pedagogical model is a modified version of Carvalho shown in Figure 1. The activities in these environments can be divided into three stages:

1. **Before class**: *Microworlds* that measure the previous knowledge and experience of the students are uploaded on the course web page and the students are asked to experiment and write what they think about them and e-mail their writings to the teacher.
2. **In class:** The teacher discusses the students' experiments and tries to highlight important concepts and misconceptions. S/he carries on the lecture and makes use of the simulations whenever needed. S/he lets the children work with the simulations, tries to make them ask questions and lets the others answer.
3. **After class–home**: Upload all the materials (simulations, lecture notes, questions to be answered, and alike) on the web page and give chance to children to review the notes and the experiments as much as they like. The students are asked to answer the questions and e-mail them to their teacher. They are allowed to discuss the questions with their parents or their friends. The students are motivated to make surveys related to the topic on the Internet and present their findings in the class.

Development of course material that will fulfill the course objectives and implementation of the teaching strategies and learning strategies

The simulations are either developed or downloaded from the Internet and organized within the course as to: (1) transform a standard lecture into a lecture based on cooperative exercises; and, (2) discover children's previous knowledge and misconceptions. In this model of teaching we expect the students to learn from each other, from the teacher, and from the process itself. Based on the feedbacks from students and results of the assessment tools, the model and the course material are modified.

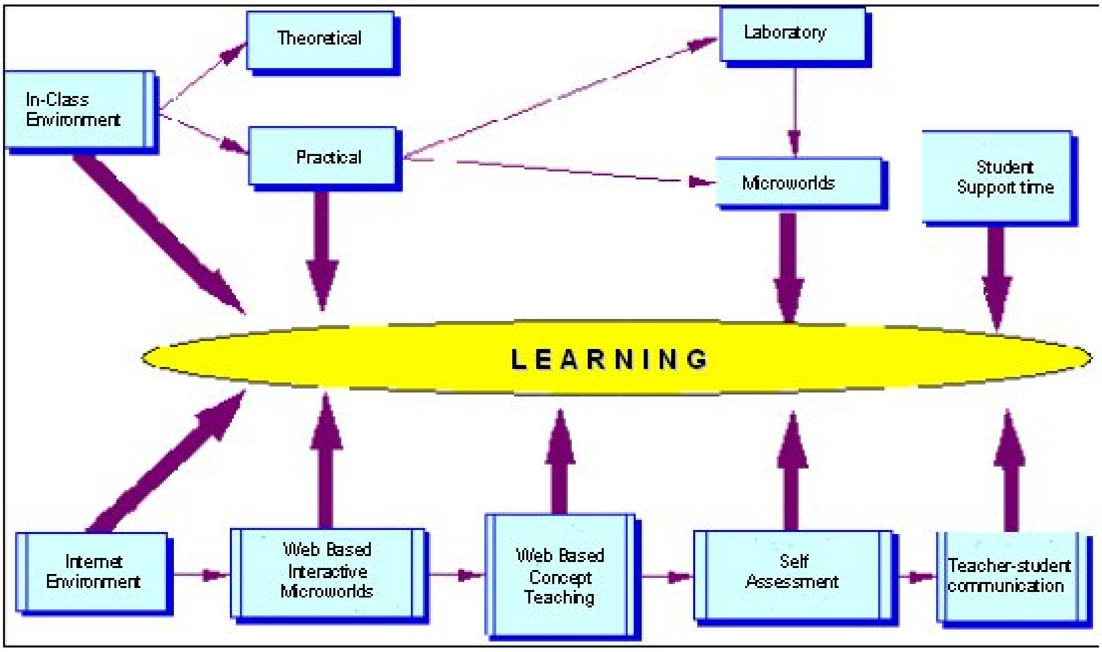

***Fig. 1** The model of the study*

DESIGN OF THE EXPERIMENT

Choosing the schools

This study is announced in FEDS[1]; Teachers from ten private primary schools responded to this announcement and attended the first project meeting. At the end of the meetings, two volunteer private primary schools were chosen. The reason why we chose private schools for our study is that these schools are donated with modern computer laboratories connected to the internet and both the students and teachers are computer literate.

The Sample of the Study

The research was limited to 120 students who were studying at two primary schools in the spring term of 2002-2003. There were 60 students in the experimental group and 60 in the control group. Students in the experimental group worked on *microworlds* and used internet as a means of communication in addition to their regular computer course in the curriculum. On the other hand, students in the control group only attended the computer course.

[1] Science Education Support System

Material

Web page: Web pages were designed both for the teachers and students. The teachers' web pages are explanations on how, when and in which ways the activities should be carried out and detailed information on students' gains, national curriculum etc. The web pages for the students include e-mail links, *microworlds*, and help pages.

Microworlds: These are related to the real life problems attained from the internet and developed by the researchers. Fig, 2 presents one of the *microworlds* used in the study.

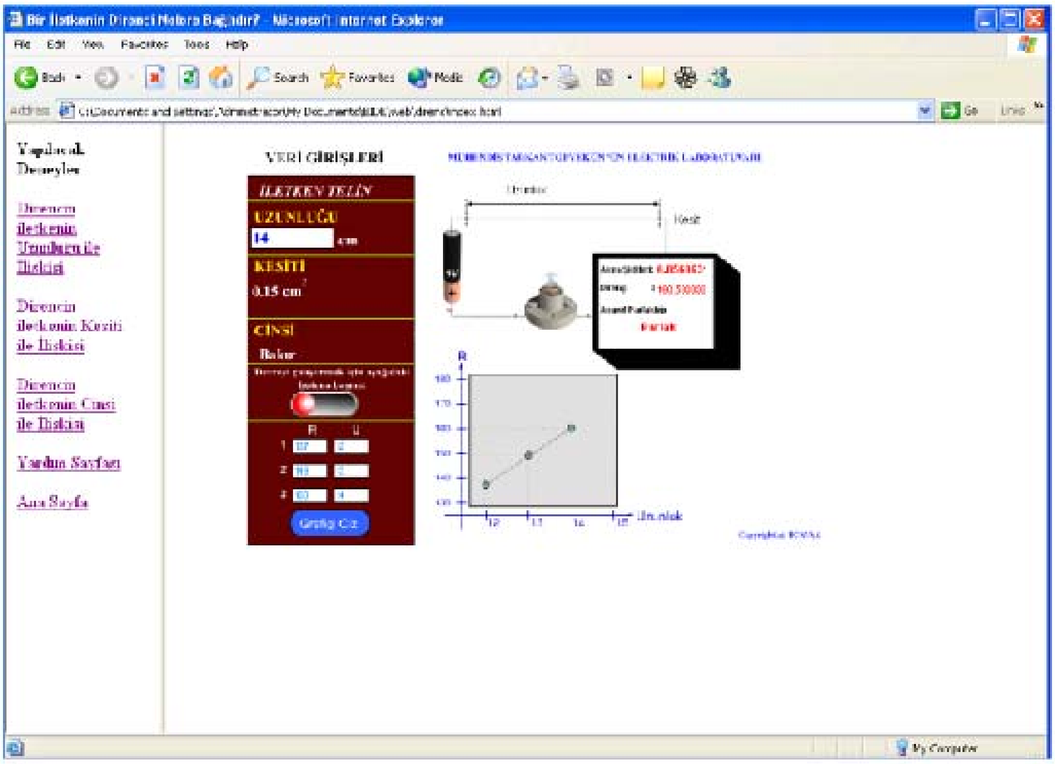

Fig. 2 *A sample of a microworld developed by the researchers*

Assessment Tools

The data of this research were gathered from pre and post tests, observation form, e-mail feedbacks, and teachers' opinions.

Pre and Post tests: Pre and post tests are prepared considering students' cognitive processing. The validity and reliability of these tests were verified with a pilot study and the opinions of the experts in science education were taken. The reliability coefficient of the test was found as 0.86; this shows that the internal validity of the applied tests is good; and its reliability is high.

Observation Form: The observation form (see Appendix 1) used is developed by the National Ministry of Education. The aim is to trace the students on their in-class and out-of-class activities related to science course. The teacher is required to fill out these forms for each student after the class. The students are graded from 1 to 5 depending on how much they fulfill the tasks.

The form consists of four sections. The first section assesses how well the student gets prepared for the class. The second section is related to the student's in-class participation. The third section assesses the student's motivation toward making research, observations and investigations related to the course material, and the fourth section assesses how much of the theoretical information can be applied into practice by the student.

e-mail feedbacks from students: The students were required to visit the web page before each course, work with *microworlds*, and e-mail their teachers about what they think and learned. The feedbacks collected via e-mails are used to assess students' learning out of the classroom.

Teachers' opinions: Teachers's opinions are taken by interviewing them to assess the applicability of the model. Some quoted passages are given in the results section.

Q	Objectives of Pre – Post tests S/he	Control		Experimental	
		Pre test %	Post test %	Pre test %	Post test %
1	makes a basic battery and explains the main part of battery.	68	65	70	83
2	connects the bulb to two terminals of the battery and shows that the bulb is lighting.	84	88	85	93
3	explains how electrons flow in the circuit and electricity currency occurs when a bulb connects two terminals of battery.	42	51	43	71
4	indicates how to realize the existence of electricity currency and measure electricity currency with ampermeter.	58	59	58	77
5	explains how electrons flow in the circuit and electricity currency occurs when a bulb connect two terminals of battery.	38	40	40	66
6	measures electricity currency with ampermeter.	33	56	35	88
7	realizes effects of electricity currency (light and heat).	20	42	20	66
8	explains how electrons flow in the circuit and electricity currency is occured when a bulb connect to two terminals of battery.	24	36	25	51
9	realizes and explains the voltage between two terminals of the battery and measures it with voltmeter.	5	43	5	61
10	realizes and explains the voltage between two terminals of the battery and measures it with voltmeter.	48	60	50	90
11	realizes and explains the voltage between two terminals of the battery and measures it with voltmeter.	44	54	45	85
12	realizes that what the resistance of a wire depends on and currency does not flow easily at each wire and conductors show resistance to currency.	37	51	38	53
13	shows that there are similarities between resistance and friction.	50	60	56	63
14	realizes that what the resistance of a wire depends on.	42	68	45	87
15	realizes that what the resistance of a wire depends on.	55	65	56	74
16	shows that the energy of electricity is transformed to the energy of heat because of the resistance.	53	60	55	90
17	explains the results wire shows resistance towards currency.	61	63	62	72
18	gives examples for resistance and its places to use.	36	54	37	70
19	describes the energy and power for element of circuit.	20	42	20	75
20	realizes that battery produces energy, bulb is a resistance and it uses energy in a circuit which includes battery and bulb.	53	63	56	83
21	sets up series and parallel circuits using battery and bulbs, draws diagrams of circuits and measures and compares the currency and voltage both in two different circuit.	20	47	19	69
22	describes the electricity circuit and explains with examples what the open and closed circuits are.	52	53	50	88
23	describes the electricity circuit and explains with examples what the open and closed circuits are.	41	50	43	87
24	describes the electricity circuit and explains with examples what the open and closed circuits are.	24	49	25	89
25	describes the electricity circuit and explains with examples what the open and closed circuits are.	27	45	31	85

Table 1. *Percentages of objectives fulfilled for each pre-post question by students in the experimental and control groups.*

RESULTS

The statistical analyses of the gathered data in this study are done using SPSS. Table 1 above describe in percentages the objectives fulfilled for each question of the pre and post tests answered by students in both the experimental and control groups. The results indicate high ratios in what students knew before treatment and after treatment. However, Table 2 shows that after the application of the pre test; there are no significant differences between the control and the experimental groups (p> 0.001). After the pre test, the mean of the control group is 10.85; and the mean of the experimental group is 11.78. After the application of the post test, the mean of the control group increased to 13.83 where it is raised to 19.89 in the experimental group. This shows significant differences between the control and experimental groups (p< 0.001). As a result of these findings, we can say that the proposed model has a positive impact on the achievement of the students in the experimental group.

Item		N	df	Mean	Std Deviation	t	p
Pre-test	Control	60	25	10.85	1.034	.220	.867
	Experimental	60	25	11.78	1.045		
Post-test	Control	60	25	13.25	1.230	.415	.000*
	Experimental	60	25	19.89	1.435		

Table 2. *Statistical analysis of pre and post tests.*

Observation Form

Table 3 summarizes the results obtained from the observation form (Appendix 1). The analyis of observation form indicates no significant differences between the control and experimental groups. This shows that the motivation and interest of the students toward the lessons are at the same level in both groups.

Item	**Always**		**Usually**		**Sometimes**		**Rarely**		**Never**	
Observations	**E**	**C**	**E**	**C**	**E**	**C**	**E**	**C**	**E**	**C**
Preparing	65	63	20	18	13	17	1	1	1	1
Participating	78	79	15	13	5	7	2	1	0	1
Making Researches and observation	24	20	56	53	12	11	5	15	3	1
Application to science	10	7	24	14	30	25	26	38	10	16

Table 3. *Findings from Observation form*

Table 3 summarizes the results obtained from the observation form (Appendix 1). The cells show the total scores calculated for the items "always", "usually", "sometimes" and "never" for both the the experimental (E) and the control (C) groups. The analyis of observation form indicates no significant differences between the control and experimental groups. This shows that the motivation and interest of the students toward the lessons are at the same level in both groups. This finding is in parallel with the argument that change in attitutes need longer time (Tavsancıl, 2002).

Feedbacks from Science Teachers

The applicability of the model used in the study content is assessed by teacher opinions, some of which are cited below.

Female Science Teacher-Private School

......I suppose that it can be used in both the learning and evaluation process. It is consistent with all the levels of Bloom; and this is very important. It is an activity which can make learning easy and which can provide stability.....

...But each student should physically connect the circuit as parallel and series, connect the ammeter and voltmeter; and know how to work them by himself; since all the analogies, except for physical and kinesthetic skills, are consistent with all levels of intelligence. Surely, it would be a good idea to support this opinion in one way or another…

Male Science Teacher-State School

....First of all, in case the laboratory where the lesson will be presented by computer, it is not suitable for the number of the class, there may be disciplinary problems or lack of concentration due to the overcrowd.....

....one of the important problems is whether the teacher has enough knowledge and skills on using the computer or not. The possible faults caused by either the disability of the teacher or of the computer may cause both to lessen the effect of the presentation and also to make students be less attentive to the lessons.

Female Science Teacher-Private School

....Since the students have complaints about the difficulty of the unit, they cannot completely perceive the topics in their minds. We cannot be efficient enough in some subjects, like the movement of electrons; because they are all abstract subjects. In this case, the topics, in my opinion, became more enjoyable with the usage of simulations and concretized examples.....

....In the end, analogies stay in the students' mind for a longer time. As a result, it is possible to provide a meaningful learning within a limited time. There may also be an oppurtunity to review at home....

We can summarize the important factors pointed out by the science teachers on the applicability of the proposed model as follows

- The students' success in science lesson is closely related to their being capable of making surveys, research, experiments and observations; as for the psychomotor, it will be very difficult for them to gain the same skills with the help of the computer. So the real laboratories are very important for the hands on activities and psychomotor skills.
- One of the biggest handicaps of the public schools in Turkey is the overcrowded classrooms. This brings a lot of burden to the teacher in responding to e-mails of the students, organizing and conducting ICT based course material.
- For efficient application of ICT based learning model, the teacher must be computer literate.
- The usage of analogies causes the students to understand the topics better and to retain them in their minds.
- The classrooms must be technologicaly sufficent.

CONCLUSIONS

In this study, we have presented a model for ICT based learning for a primary science course and have shown that it can be applied successfully if efficient support to teachers is provided. This support includes the provision of learning materials like *microworlds*, course web page and homework assignments. We have applied the presented model on "running electricity" topic in "Electricity Directing Our Lives" unit in primary 6th grade science currriculum. To asesess the efficiency of the model, it is applied to control and experimental groups which initially showed no significant difference. Post-tests show that the experimental group has achieved better than the control group.

According to the opinions of the teachers and the assessmet results we can summarize other conclusions in the following items:

- Teachers must be supported in using the technology and persuaded about the benefits of ICT based learning. They should also be provided with course material and application examples.
- Even though most of the teachers agree on the positive effect of *microworlds* in learning abstract concepts, they say that hands-on experiments should not be replaced with them.
- Lecturing and ICT should be well balanced with the primary focus on the learning of the course material. Technology should be used as much as needed and in the right time.
- Assignments are important aid for self study. Putting all the course material on the web enables the students to review the lectures and work on the microworlds at home. Students are found comfortable while using computers and writing e-mails.
- Teachers need time for answering e-mails.

As a final statement we agree with Twining that the possible impact of ICT in education needs shared understandings (visions) about the reasons for using ICT in education (Twining 2002). We hope that this work will help researchers to prepare and apply ICT based primary science course.

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Appendix 1

Student Observation Form

Name-Surname: Class: Student Number:
Explanation: This form is for observing the students' participating in the course activities.

STUDENT'S GAINS		LEVEL				
		Always	**Often**	**Sometimes**	**Rarely**	**Never**
		5	**4**	**3**	**2**	**1**
I. PREPARATION						
1	asks for resources about the course content					
2	finds resources					
3	knows how to access resources					
4	comes to class with different resources					
5	comes prepared for the course					
TOTAL						
II. PARTICIPATION IN ACTIVITIES						
1	speaks whenever have an idea					
2	speaks when asked					
3	opinions are original					
4	asks original questions					
5	questions reveal attention					
TOTAL						
III. INVESTIGATIONS - RESEARCH –OBSERVATION						
1	collects information from different resources					
2	makes research from different resources					
3	does homework painstakingly					
4	draws reasonable inferences after observation					
5	can make generalizations					
TOTAL						
IV. APPLICATON TO SCIENCE						
1	infers unknown from known					
2	draws graphics and charts					
3	applies appropriate method for the experiment					
4	derives concepts and results from experiment					
5	can present the results of experiment					
TOTAL						