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Understanding Change: Perceived Impacts of Educational and Information Technology (E&IT) on Teaching and Learning

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ABSTRACT

Change in education is hard and complex since crucial factors, mostly hindering ones, emerge during implementation. Current literature shows that this has been proved to be true throughout the implementation of Educational and information technology (E&IT) in education in every parts of the world. For the practitioners, undersdanding change is the first step and critical point to move forward. In this study, science teacher educators' and prospective science teachers' understanding of E&IT and its usefullness in taeching and learning science were explored by using multiple methods in the case selected. This study includes three secondary preservice science teacher education programmes – i.e. Physics, Chemistry and Biology. The student teachers (STs) from these three programmes are expected to teach their specialist subject in secondary schools – i.e. 15-17 age group- after their graduation. Results showed that there were some patterns in understanding the use of E&IT in science education among the participants. E&IT was perceived as information sources, presentation tools, facilitator and a medium to change current styles of teaching and learning science. The results were derieved from the participants' actual practice and their perceptual understanding of the use of E&IT in science education..

Keywords: Educational and information technology, understanding change, prospective science teachers

INTRODUCTION

The main purpose of educational change is to make an impact on the practitioners' beliefs, skills and perspectives. However, the practitioners' understanding of the intended change or an innovation differs from each other (i.e. through different subjective realities). Fullan (1991) argues that in the initial phase of the change or innovation utility, practitioners' understanding and potential benefits of the innovation must be clear for people involved in the process. In other words, individuals and institutions ought to know where they are heading (Hargreaves, 1997). Fullan (1991) and Goodson (2001) argue that individual understanding of any change and innovation is the critical point in the change process. The widespread acknowledgement of using E&IT in education is based on the assumption that E&IT has a critical role to play, resulting in improvements in education. A crucial challenge teachers face in teaching science with the help of E&IT is undoubtly to find ways to integrate E&IT into their teaching. This requires first an understanding of E&IT and its uses in science teaching and learning.

Using E&IT in teaching and learning science do not only create challenges for the practitioners (i.e. all parts in educational settings) in acquiring technical skills needed, it also requires a new understanding of delivering educational activities in and out of schools. That is, E&IT provides new teaching-learning environment and gives way to new approaches to teaching and learning. Recently, integrating E&IT into educational institutions in general and initial teacher education in particular is a crucial issue in Turkey. STs should be educated in integrating E&IT into their teaching and learning activities, and therefore be able to adapt themselves to this new teaching-learning environment with a new understanding of the change that E&IT offers in teaching and learning science. Determining how they understand E&IT and its use in science teaching and learning towards the end of their pre-service training is thought to be crucial since it is believed that they will teach the way they were taught, employing their understanding, technical and application skills.

WHAT CAN E&IT CHANGE IN TEACHING/LEARNING SCIENCE?

E&IT has many qualities that make it so important in the learning and teaching process. There is, of course, no single best use of E&IT in teaching and learning activities. OTA (1988) points out twelve key capabilities of the technology in education. These most promising uses and demonstrations of technology in education are:

- Drill and practice to master basic skills
- Development of writing skills
- Problem solving
- Understanding abstract mathematics and science concepts
- Simulation in science, mathematics and social studies
- Manipulation of data
- Acquisition of computer skills for general purposes, and for business and vocational training
- Access and communication for traditionally unserved populations of students
- Access and communication for teachers and students in remote locations
- Individual learning
- Co-operative learning
- Management of classroom activities and record keeping (p. 12-14).

As far as cognitive/constructivist teaching approaches are concerned, learning is an active process, and students construct their own meaning and understanding of their experiences in this process (Naylor and Keogh, 1999) as "active participants rather than passive receivers" (Newton and Rogers, 2001:38). E&IT can shift the balance from traditional teacher-centred classroom practices to more student-centred ones, providing rich opportunities for students to take control over their own learning and construct their own knowledge. In science teaching/learning, *practical activities/enquiry-based teaching* (Newton and Rogers, 2001) or the *application of science* (Turner, 2000) are crucial to secure students' benefits regarding their conceptual understanding and procedural understanding of science (Bencze, 2000; Newton and Rogers, 2001). "The primary goal of science education is to contribute to the intellectual development of learners through the acquisition and application of scientific knowledge, skills and understanding" (Newton and Rogers, 2001:139).

There are many studies which illustrate that E&IT might contribute to enhancing the quality of science teaching and learning. Wellington (1999) reports on the *Chemistry School* Project, which was a collaborative initiative, jointly funded and organised by the Nuffield Curriculum Projects Centre and New Media Press, aiming to enhance the teaching and learning chemistry at key stage 4, that E&IT is seen as a valuable tool by the teachers.

In his study, he classifies teachers' perceptions of using E&IT in their chemistry teaching. Teachers see the 'added value' of E&IT as follows; visualisation, differentiation, variety of approach, effects on attitudes and motivation of pupils and teachers. In the same study, students' perceptions are not much different from their teachers'. Newton and Rogers (2001) describe some clear contributions of different E&IT sources to teaching and learning science in their book, *Teaching Science with E&IT*, suggesting the way to incorporate them into teaching science in order to secure their benefits (see also OTA, 1988/1995; Ross et al., 2000; Becker and Ravitz, 1999; Rogers, 1990; de Jong et al., 1998). McFarlane and Sakellariou (2002) state that E&IT can either be used as an integral tool of laboratory-based practical activities them or as a virtual alternative to real practical work. McFarlane (2000, cited in McFarlane and Sakellariou, 2002:221) proposes a model of the iterative process of science to structure science teaching/learning environment, providing some examples of current use of E&IT alongside this process, as illustrated in Figure 1.

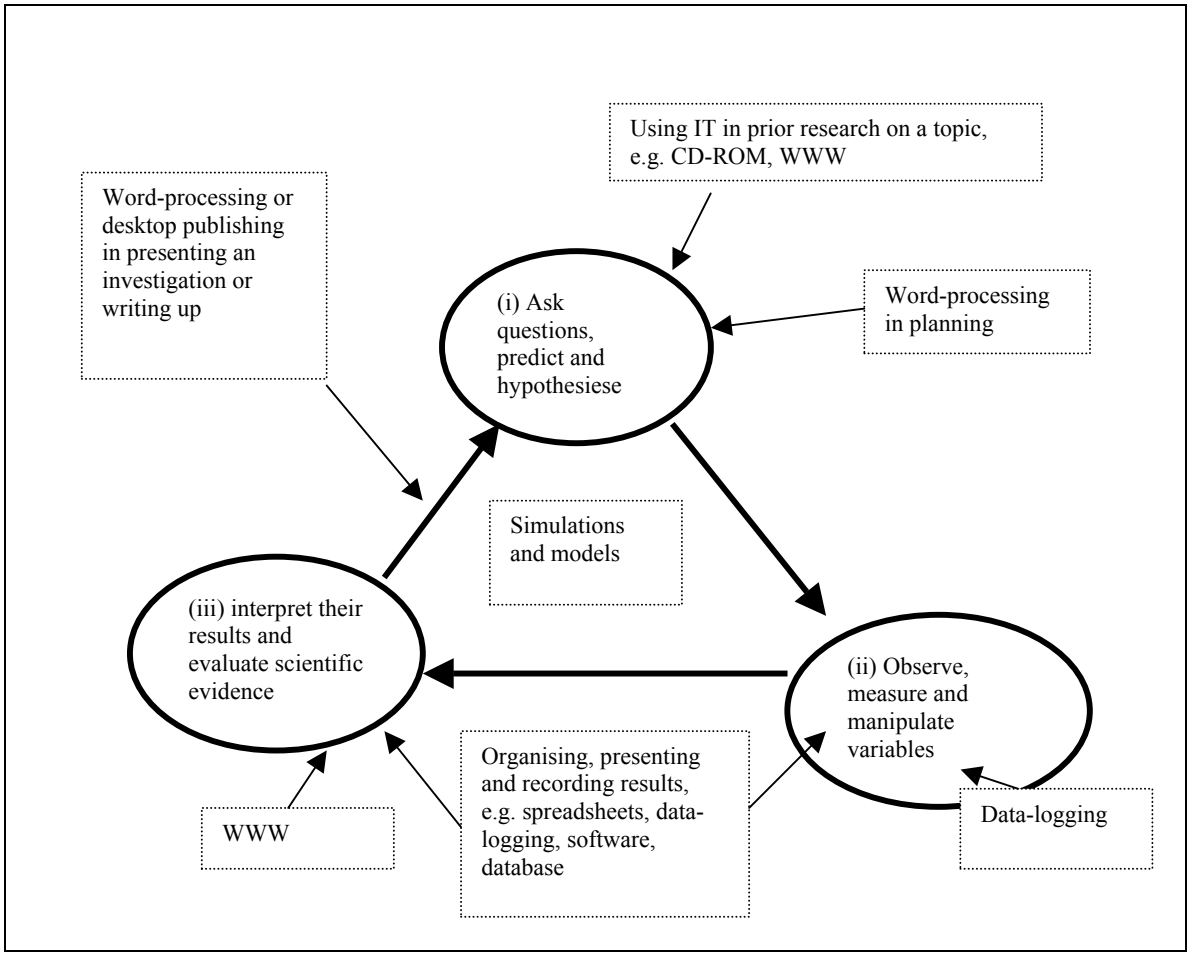

Figure 1. *A model of the iteractive process of science that can be used to structure experience of science at the school level with some examples of current use of E&IT (McFarlane, 2000, cited in McFarlane and Sakellariou, 2002:221)*

In any kind of educational innovation, individuals' involvement, ownership, and commitment are crucial to secure the potential benefits. Tebbutt (2000) points out that there is a danger of being unsuccessful by expecting too much, too quickly, from teachers, and paying too little attention to the detailed reasons why teachers find difficulty in incorporating E&IT into their teaching. It is evident that the practitioners' undersdanding of E&IT and its use in teaching and learning science is crucial since they ought to know and understand where they are heading.

METHODOLOGY

This article is a part of a case study, in which the participants' understanding of E&IT, their E&IT capability, their attitudes and factors affecting their practice in using E&IT to teach their subject area were explored in detail. In this article, however, the focus was to investigate teacher educators' and prospective science STs' understanding of E&IT in teaching and learning science. Thus, the main research question was 'how STs and teacher educators understand E&IT and its uses in teaching and learning science?'. In investigating this process, the participants' perceptions of E&IT and its value in science education were explored by using multiple methods in the case selected. This study includes three secondary preservice science teacher education programmes – i.e. Physics, Chemistry and Biology in a Turkish Faculty of Education. It is intended to explore what happens in real classroom settings, and therefore to explore teacher educators' and STs', as real actors involved in classroom practices, perceptions and applications of E&IT. The STs from these three programmes are expected to teach their specialist subject in secondary schools – i.e. 15-17 age group- after their graduation.

In this study, case study approach was used, adopting *between method* triangulation, in the main study (i.e. document analysis, observation and semi-structured interview as qualitative methods and questionnaire as quantitative one only for STs). In this article, however, data gathered from the observations, interviews and STs questionnaire were elaborated. It was assumed that the knowledge related to research question comes from the natural context, the researcher's interpretations and the subjects' understanding and interpretations of the setting with their own words, observations and experiences. Thus this requires a qualitative approach, interpretivist in its epistemology. Miles and Huberman (1994) point out that sampling involves decisions about which people to observe or interview with, and also about settings, events, and process. Table 1 applies these principles in terms of their relevance for this study.

Table 1. *The Description Of The Sample In The Study (Adapted From Miles And Huberman, 1994:30)*

Sampling parameters	***Sample Chosen in the study***
Settings	Faculty of Education, classrooms, laboratories.
Actors	Lecturers from three pre-service science teacher education programmes with different characteristics (e.g. experience, academic and administrative responsibility, specialist subject), STs from each programmes with different characteristics (e.g. subject area, gender).
Events	Actual use of E&IT and other technology, teaching, lecturers' and STs' roles during teaching/learning activities.
Process	Using E&IT in practice, teaching style and format, E&IT integration process.

The participants were in two groups: lecturers and STs from each programme. All STs from each programme were asked to fill in the questionnaire, so 128 STs from three programmes participated in filling the questionnaire in the main study. All STs had at least an E&IT related course before the study. At the end of the questionnaire a statement was added, in which the STs were asked whether they wanted to take part in further study, that

is, whether they wanted to be interviewed, and to write their name, programme, phone number and e-mail, if they had one. All STs, who agreed, were interviewed. Apart from this, three more STs, who had not wanted to be participants from the beginning, were asked to be interviewed after observation. This was because of their role in the classroom during observation, and the researcher took notice and wanted to acquire their understanding, perceptions, and use of E&IT in teaching/learning. So, 29 STs, out of 128, from all three programmes participated in interviewing. Six lecturers were asked to be interviewed and observed in the classroom. They developed their technical and pedagogical skills with their own individual efforts. All lecturers took part in the study voluntarily. So, 3 lecturers from physics, 1 from chemistry, and 2 from biology programmes were interviewed and observed throughout six weeks. All the participating lecturers were observed throughout three lessons, either subject (i.e. physics, chemistry and biology) or method courses (i.e. courses related to teaching and learning). The lessons observed were randomly selected. During observations, the lecturers' and STs' uses of E&IT to facilitate the teaching and learning processes were taking into account. All interviews were done after the observations.

Scott (1996) states that a research paradigm can be identified by its ontological, epistemological and methodological positions. He also points out that a research paradigm can be distinguished by some evaluative criteria in view of the quality in research. In this study, the researcher took some precautions to enhance credibility (validity). First, the researcher had been a member of staff before the study for three years, so he had enough experience in the same culture - prolonged involvement (Robson, 1993). Second, it was assumed that the use of different methods of gathering data would enhance the credibility - triangulation (Robson, 1993; Denzin, 1989; Stake 2000). Member checks were also used to improve credibility. In this process the participants were requested to examine raw data, and they were asked to review the data for accuracy to improve the credibility – member checks (Robson, 1993). In order to enhance the dependability (reliability), the researcher also has piloted all materials having been used in the data gathering process. From the beginning in the study the researcher provided a clear and "thick description" (see Lincoln and Guba, 2000) of the research process including underlying theories, research methods and procedures in order to understand findings. It was hoped that this might be helpful for other researchers interested in the study to warrant that case-to-case transfer or generalisation. As Stake (2000) discusses, it is useful to understand a full and through knowledge of the particular, recognising it in new and different settings. He uses the term *naturalistic generalisation* and sees it as intuitive and empirical. Quoting Lincoln and Guba (2000), he thus sees case studies as "they may be epistemologically in harmony with the reader's experience and thus to that person *a natural basis for generalisation*" (p.36).

FINDINGS AND DISCUSSION

In this section the participants' understandings of the innovation, E&IT, are analysed and discussed regarding its role in the new teaching-learning environment, its value and potential. The lecturers' perceptions of E&IT are derived from interviews, and actual illustrations of their perceptions were sought from the field notes during observations. The STs' perceptions, on the other hand, are revealed through questionnaire (i.e. through open-ended questions – what do STs think about E&IT and its use in teaching and learning science? What is the superiority of E&IT over other teaching and learning activities? Do they use E&IT and why in teaching and learning), interviews (through questions such as, do you use any E&IT resources?, with probes-why, why not, how often-, what do you think about the main benefits and drawbacks of E&IT use in science teaching and

learning? Do you think that E&IT changes th way to teach and learn science?) and observations (i.e. taking field notes about STs' use and role during lectures.

Lecturers	E&IT as information sources	E&IT as presentation tools	E&IT as a facilitator	E&IT as a medium to change current style of teaching and learning	Constraints
L1	Variety of information, Easy to reach	Easy and effective presentation	Abstract concepts to concrete, motivation, drill-and-practice, help with learning diffic.	Constructive learning environment	Clear targets needed, distraction after a while, costs, pre-planning needed and time consuming for teachers
L2	A new way of reaching knowledge	Effective presentation*	Visual, constructing and testing your own concepts, students own ways of reaching knowledge	Student-led activities*, collaboration*	Wrong or misleading models or simulations, ready knowledge may lead students to being reluctant
L3	Accessing a vast amount of knowledge	Effective presentation*	Abstract concepts to concrete!, safety, motivation, drill-and-practice, helps for slow learners	Student knows the ways to reach information, and construct his/her own knowledge	Skepticism about package programmes, modelling and simulation
L4	Accessing and storing variety of information	Effective presentation*	Storing, abstract concepts to concrete, safety, motivation	Student-led activities*, student-centred*, collaboration*	Skepticism about package programmes, modelling and simulation, lack of lab. skills, skepticism about www information
L5	Easy access to vast amount of information	Effective presentation*	Abstract concepts to concrete, visual	Student-led activities and presentation*, collaboration*	Cost, loss of motivation after a while
L6	Up-to-date information, variety of information	Effective presentation and demonstration*	Support with different sources of information	Developing higher order thinking	Getting bored if used always

Table 2. *The participating lecturers' perceptions of E&IT.* **Observed*

The findings of data analysis revealed that the participating lecturers' perceptions of E&IT vary, as can be seen from Table 2. The data suggest that they see and understand E&IT as; information sources, presentation tools, a facilitator, medium to change current style of teaching and learning. These themes emerged from their beliefs; and personal and academic uses, reported or observed.

E&IT as	facilitators	Information sources	Presentation tools	Medium to change current style of teaching and learning	Constraints
The Participating STs	Visual* Abstract concepts to concrete* Motivation* Saving time* Drill-and-practice	Variety of information sources* Saving and constructing your own information source, Accessing a vast amount of knowledge by means of the Internet*	Effective presentation* Time savers Whole class presentation by means of OHP and data-show, using big white screens* Motivation*	Active learning Individualised-learning Providing constructivist teaching and learning environments Flexibility Collaboration and cooperation*	Time-consuming in preparation stage* Lack of students' experience of E&IT Selecting the right source for the right task is crucial Teachers' competence on using and managing E&IT in teaching is a must Cost Skepticism about class management* Distraction Lack of social interaction Lack of enough educational materials over the Internet in Turkish

Table 3. *The participating student teachers' perceptions of E&IT.* *Observed

As can be seen from Table 3, the participating STs' perceptions of E&IT vary. The data suggest that they see and understand E&IT as; information sources, presentation tools, a facilitator, medium to change current style of teaching and learning as well.

In both groups of the participants, even though they had never used E&IT in their teaching and learning activities, some individual perceptions and understanding of E&IT reflected popular knowledge rather than reflection upon their actual practice, among STs in particular.

Next, each emerging themes derived from the data will be elaborated on to understand how the participants perceive and appraise the use of E&IT in science teaching and learning.

E&IT AS INFORMATION SOURCES

A. For Lecturers

Although all participating lecturers perceive E&IT as information sources, their perceptions of the ways to benefit from these sources vary. L1, L5 and L6 tend to perceive E&IT as an ever accessible library in which one can reach the information whenever they need by means of the Internet, data-bases, CD-ROM, and so forth, and use it in order to explain the topics to students in the classroom. L1 and L6 also use the Internet for their own academic studies, reaching up-to-date information related to their subject area. L6, for instance, reported that:

> "Producing original information should be the most crucial part of the academic researchers' duties duplication is for nothing. Knowledge has been produced so fast that only the titles of produced studies within 15 days might be listed in a 100-page leaflet. Thus, using E&IT is the easiest and fastest way to realise what happens around the world and follow the agenda I sometimes use the information I got from the net in my lessons, making it easier to understand, so that the students could understand easily, and present it to their classmates". (L6, Int.)

L2, L3 and L4, on the other hand, mentioned that E&IT, especially the Internet, can be used in an individualised-knowledge construction way in which individuals, students or lecturers, can set their own tasks to search for, organise and analyse information with their own pace. In this vein, L3 mentioned that:

> "I personally think that we, as lecturers, should direct or guide students through a new approach in which they can themselves discover the ways to reach the information they need and construct their own learning environments and knowledge…Technology can serve this purpose very efficiently". (L3, Int.)

L4, on the other hand, raised an emerging issue about the reliability of information available over the Internet:

> "I have used the Internet to reach up-to-date information related to my academic studies, and also sometimes to prepare lesson plans and produce hand-outs for students… Even though there are a great deal of information over the Internet, that does not mean that all the information presented is valid and reliable. Thus, this must be taken into consideration seriously by the users, I do not know, by simply checking who put the information over the Internet or looking at the references" (L4, Int.)

B. For STs

As the participating lecturers differ from each other in making use of E&IT as information sources, STs' perceptions of benefiting from E&IT as information sources were also twofold. Firstly, the data revealed that the STs perceive E&IT as information sources, providing accessible vast amount of information available anytime and anywhere, in which mostly the teacher directs and sets the rules. However, four STs made complaints about lack of available educational materials over the Internet written in Turkish language:

> "You can reach varieties of information through the Internet, yet from my own experience I must say that there is very little information about different aspects of education written in Turkish language. When I was writing an assignment for the course, Special Teaching Methods, I attempted to search for information about the topic I selected but, as I said, I could not find that much useful information over the Internet. Having said this, I believe that teachers can use

> these tools in order to gather information to prepare his/her lesson plans I know there are lots of educational sites over the Internet in English or other languages, which I do not understand" (PT9, Int.)

Secondly, they also perceive E&IT as information sources which the users set their own targets to search for, organise and analyse the information through independent uses. One illustration of this sort of understanding and use of E&IT was observed in the Biology programme. A group of eight STs had planned and presented a two-hour presentation, and three of them were interviewed afterwards. In these two lessons, their use of E&IT as information sources is worth mentioning here. They first selected a topic to do a research, discussing it with the lecturer, L5. Then, they came together and decided about individual roles in the process. The STs used the Internet in order to gather some theoretical information about sound and light pollution and downloaded the information on a diskette. Then they transformed the theoretical information into presentable format using transparencies for OHP. They also downloaded some pictures from the Internet to illustrate light pollution in daily life. For illustrating sound pollution, other STs used a digital camera which could be linked with a TV or computer. They took some examples from different parts of the city of Trabzon and measured the level of sound, including a drama-play by them. During the presentation, they compared the theoretical information gathered from the Internet and other sources such as books, journals, newspapers, and so forth, along with the data gathered from the real life. By doing all this they incorporated E&IT into their planning, preparation and presentation processes. They, in a way, constructed their own data base as well as used E&IT, particularly the Internet, as information sources. One of the STs from the Biology group, BT4, expressed himself after the presentation as follows:

> "It was excellent… First of all, what we have done was a research-based work. We searched for information about sound and light pollution in and abroad mainly by means of the Internet. Then we tried to discuss the health and environmental problems they might cause and compared the theoretical values with the values we measured in the daily life… To be honest I could not imagine this kind of lesson throughout my school life. I personally have learnt a lot about the topics we focused on and the use of technology to deliver the lesson After the lesson we have got lots of positive feedback from our friends about the presentation". (BT4, Int.)

As Grabe and Grabe (1998) discuss the active role of the student in the learning process, the information was not "presented to the students in some kind of final, distilled form" (p. 7). They argue that students have to "dig for" the information and they have to "pull together bits and pieces of information from several sources, generate personal summaries, and make decisions" (p. 7). In the lesson mentioned above, as Grabe and Grabe (1998) describe, active involvement of the STs was not just physical but mental as well, throughout the processes of information gathering, planning and presentation. Selinger (2001:88) argues the potential of E&IT in an authentic learning environment that:

> "the idea that teachers are fountains of knowledge and that children are empty vessels waiting to be filled with the knowledge and wisdom of their teacher is untenable in the information age. The amount of available knowledge and the breadth and depth of it are far beyond the realms of most teachers as is their control of learners' access to it… teachers need to encourage skills in which learners seek new information and consider alternative viewpoints, question their sources, and make judgements about the validity and reliability of evidence and information presented to them from a range of sources".

She redefines the role of the teachers as facilitators in the information age rather than just as knowledge transmitters.

C. Summary

Data revealed that majority of the lecturers, including some STs, were aware of that they need to change the traditional role of the teacher to exploit the full potential of E&IT, from knowledge transmitters to facilitators/guides.

E&IT AS PRESENTATION TOOLS

A. For Lecturers

All the participating lecturers use E&IT and other technology to present information in the classroom. This was the most common use of E&IT among the lecturers during their teaching activities, as far as interview results concerned. For this purpose, they mostly use OHPs and data-show. For demonstration, they mostly use video-TV set and slide projectors. During observations, it was observed that the technology users, L3 and L6 made use of E&IT not only to present pieces of information, but also to discuss the topics presented and/or demonstrated. By doing so, they attempted to get students' attention through whole class discussion, and interaction among STs, the lecturer and the E&IT source was created. As discussed earlier in this section, the lectures mostly used OHPs during presentation. To produce transparencies, they use computers, the Internet and printers. L1 reported that:

> "We used OHPs and data-show to make presentations more effective. We, as lecturers, make use of presentation tools such as OHP and data-show. One of the main reasons is to model how presentation could be carried out, using technology, for the STs. And we encourage and push STs to use them as well by giving them group tasks related to the use of technology in their subject teaching. I can say that they are enthusiastic about using new technology". (L1, Int.)

B. For STs

STs' questionnaire results showed that one third of STs reported that they had made use of technology in teaching and learning activities. All technology users had used them as presentation and demonstration tools, such as OHP, slide projector, data-show, TV-video set and computers. All STs of Physics programme interviewed mentioned that they presented their assignments to the classroom, using computers and data-show, at the University, while taking the E&IT-training course. Some of them also made use of E&IT as presentation tools in other courses, yet this time their most commonly used technology was OHP. Half of the Chemistry STs mentioned that they only used OHPs as presentation tools. Biology STs, on the other hand, made use of different tools, such as slide projector, OHPs, TV-video set and computers, to design their presentations.

> "I used OHP twice to present my assignments to the classroom. I preferred OHP since it is easy to use and due to the big white screen efficient to whole class presentation, every student can see what you are talking about… In this sense, technology is a new aspect in teaching profession". (PT2, Int.)

> "I only used OHP since there are no many other technologies provided here to us". (PT4, Ques.)

> "I used OHP to present my research report for the course, field Study… Easy to use and saves time". (CT5, Int.)

> "You saw yesterday, as a group, we used OHP, TV and computer to present our assignment to the classroom… These tools make presentation interesting for students and motivate them… The

> preparation of these two lessons which you observed had taken four days, but it was great at the end". (BT6, Int.)

Surprisingly, despite the fact that the majority of the participating STs made use of E&IT or other technology in their learning, only one ST mentioned that he actually used E&IT in his teaching placement school.

As stated earlier, the lecturers usually use OHP as a presentation tool. L3, for instance, reported that

> "In my teaching activities, on the other hand, I use OHP and data-show very often in the computer-assisted science teaching course, as presentation tools, which make the presentation more effective and easy. At the same time I know that my use of technology may help the students to understand its potential as presentation tools". (L3, Int.)

L5 and L6 make use of different technological sources as presentation and demonstration tools. They very often use slide projector, OHP, and TV-video-set. They use them to present pieces of information; or demonstrate events, or samples from natural life, such as a micro-organism, cells of different plants, and natural habitat of the livings. As illustrated by both L5 and L6, it could be said that the kind of E&IT sources having been used by lecturers varies regarding their subject areas.

C. Summary

In conclusion, the lecturers perceive E&IT and other technology resources as effective tools for presentation and demonstration. They incorporate them into their daily teaching activities for this purpose through their own uses and/or the STs' uses. They also perceive that the use of technology as presentation tools saves more time even though they had to spend more time in the planning and preparation of the presentation materials.

E&IT AS A FACILITATOR OF TEACHING AND LEARNING

A. For Lecturers

As discussed earlier, the use of E&IT in teaching other subjects can improve students' learning and enhance the quality of teaching, facilitating the processes of teaching and learning (Grabe and Grabe, 1998; Loveless et al., 1995; Newton and Rogers, 2001). In this study, the participants reported some added values of E&IT as facilitators of teaching and learning. All participating lecturers and STs believe that visual aids of E&IT can help students to improve their learning of concepts and events in science through simulations and modelling. They all also emphasised that there are many concepts and events in science, which might not be understood, or misunderstood by students by using the old traditional ways of teaching. They all believe that E&IT has the potential to facilitate the teaching and learning process of these subjects. The following quotations from the interviews exemplify their perceptions of E&IT as facilitators:

> "In fact, there are high expectations from E&IT, which I believe some of them can be met. First of all students can reach the information very easily and fast. They can watch some *abstract concepts and events* in a more *concrete* way on a screen… If you *direct and guide* students, they can *design experiments* in Physics, *see* them on a screen and *share and discuss* them with others. E&IT can help *students with learning difficulties* through the use of *drill-and-practice*. It may also *motivate* students… In this processes the role of the teacher is very crucial. Students must be *directed and guided* very well". (L1, Int.)

> "In Physics there are lots of *concepts and events which are not simply observed in real life and are dangerous* to be experimented in laboratories. I believe that students learn best by doing actual experiments in the Physics laboratories, but if it is not possible to carry out these experiments, what should we do? in that case, it seems that the best way is to make use of E&IT by using *simulations and models* to improve students' learning… Having said this, *the quality* of software or educational package programmes must be taken into account carefully… Simply, E&IT can *stimulate* students and help them to *construct* the new concepts in their minds. In this sense, E&IT has the potential to provide more *real-like experiences* for students through *visualisation and sound effects*". (L2, Int.)

B. For STs

STs used various terms in order to define the added values of E&IT in science teaching and learning activities. The most commonly stated value of E&IT was its *visual effect*. Most of the STs believe that the more students use their sense organs, the more effective teaching and learning will be. Their comments on the values of E&IT as facilitators were very similar to each other. As far as the interview and questionnaire results, they see E&IT as devices and tools to: (1) make *abstract concepts and events visual*; (2) *stimulate and motivate* students; (3) save *time*; (4) increase *productivity*; (5) help *slow learner* and *students with learning difficulties to drill-and-practice*; and (6) support *active learning*. Following excerpts exemplify the STs' perceptions of E&IT as facilitators of learning and teaching:

> "We know lots of thing about Physics since we generally memorise the subjects we have been taught through traditional teaching approaches, but we cannot understand or interpret what happens in reality for most of the subjects. With its *visual and sound* effects, technology can help students understand the events or concepts better… Through students' active involvement, E&IT can also help to develop their higher order thinking by questioning and discussing what they observed or generated from E&IT sources… In this context, the teacher should become a guide rather than knowledge transmitter. The student's role, on the other hand, should be knowledge seeker or researcher". (PT5, Int.)

> "The concepts or events we learn in schools are abstract things. Take a chemical reaction, for instance, it is hard to understand what really is happening during the reaction. The use of software can improve learning. This also motivates students". (CT1, Int.)

> "During taking the course [Computer Assisted Chemistry Teaching] last year we used a software, enabling us to do experiments on a computer screen regardless of any danger. You can try and learn everything about the event you have chosen. You can control the variables or change them and their amounts. In a way you have a direct interaction with the event and computers… You can see the reactions visually, which is very important for deeper understanding". (CT3, Int.)

> "To change the traditional teaching styles which are inefficient and should be buried in the history of teaching and learning, teachers should use technology… Students must be guided to search for information and construct their own knowledge, as we did yesterday". (BT6, Int.)

C. Observations

During observations, the lecturers' and STs' uses of E&IT and other forms of technology were about facilitating the teaching and learning processes. Observations took place in four class-hours out of 18. These observations were student-sensitive and research-based in all these lessons. STs who had responsibilities during these observations used different sources of technology to share their own knowledge and research results with their friends through classroom presentations. During these observations, the lecturers' roles were as guides or facilitators. Even though most of participants perceive or make use of E&IT as facilitators of teaching and learning processes, very few of them had some doubts about the

value of the use of E&IT in learning. L3, for instance, was skeptical about the benefits of using simulations, models and drill-and-practice. He reported that:

> "By means of technology you can make the concepts, which are mostly *abstract* and hard to comprehend, more *graspable*. I do not give any response to the question 'how much' beneficial. However, in my point of view it is still more effective than traditional approaches". (L3, Int.)

L4 also made some comments on models and simulations in Chemistry teaching and learning, mentioning that the teacher has an important role to play during the use of these kinds of software: s/he must warn students that the observed reality on a screen is not the true reality but just a model or simulation to understand the things better. L5 and L6 have made use of E&IT and other forms of technology for the purpose of demonstrations. L5 reported during interview that he has especially used slide projector to demonstrate the pictures of plants and other organisms. He also emphasised that: "*visualization* is very crucial in teaching and learning Biology. In this sense, E&IT can be of a great help for teachers to explain the subject and for students to improve their learning". Likewise, L6 also mostly have used slide projector and OHPs for the same purpose. He also set up a new system in Biology laboratory, in which it enables him to *demonstrate* "micro-organisms, bacteria and ferments under microscope, using a camera and TV" to whole class. The students' involvement in these lessons was mental rather than physical, through the discussions led by the lecturer. Apart from L1 and L6 lessons, during observations, there were some lessons in which the STs fully participated in through activity-based and research-based works and discussions. Grabe and Grabe (1998:27) points out that "the emphasis in the activity-based learning shifts from the transmission of information to an emphasis on: asking critical questions, finding goal-relevant information, evaluating and integrating information to create personal knowledge, and communicating effectively".

D. Summary

Data suggest that the lecturers and STs participated in the study made use of E&IT as facilitators even if it has not been so regular, in which the use of technology facilitates the processes of teaching and learning, through: visualisation, sound-effects, collaboration and cooperation, enhancing productivity, saving time, information sources, flexibility and individualised-learning opportunities.

E&IT AS A MEDIUM TO CHANGE CURRENT TEACHING STYLES

A. For Lecturers

Underwood and Underwood (1990), Newton and Rogers (2001), Grabe and Grabe (1998), Loveless et al. (2001) and many other researchers argue that E&IT has the potential to change classroom practices from traditional teacher-centred to student-centred. Loveless et al. emphasises the roles of the people during the change, pointing out that "*technology does not change the practice, people do"* (2001:73). Data revealed that all the participating lecturers believe that E&IT can be very valuable to provide student-sensitive learning environments even though their points of view and uses vary in formats of delivery. Here the participants' perceptions of E&IT as a change agent are to be discussed, and the impact of E&IT on their teaching practice will be analysed and discussed in detail later in this section. The following quotations exemplify their perceptions of E&IT as a medium to change the nature of teaching practice:

> "If you use these technological sources through teacher-centred ways like a demonstration or presentation tool, you cannot benefit from the potential of E&IT much. I believe that students should use these sources and do in and out school's activities. Teachers should create *constructivist learning environments* for students, and E&IT can be very helpful for doing this. For this to happen, the first thing to be done is to educate the user about how they can benefit from these sources… That means that the basic objective is to give students *responsibilities*, put them at *the centre of activities*". (L1, Int.)

> "We must use E&IT for *student-led activities*… Teachers do not provide all the knowledge in the classroom. E&IT has created a new opportunity for all, which is to search for more information about the subject you were taught… To be honest, this is the most crucial point of which I like technology. As *a group or individuals*, students have the opportunity to search for information and share with their friends and teachers". (L2, Int.)

The lecturers used the terms 'constructivist learning environment', 'student-led activities', 'new way to reach information', 'knowledge construction', 'collaboration', 'higher order thinking', 'individualised learning' in order to describe the potential impacts of E&IT on science teaching and learning. These concepts have been used and defined within the constructivist pedagogies. Having said this, data also revealed that all lecturers believe that E&IT can at least enhance the quality of traditional teaching approaches during whole class presentation and demonstration even when teaching approaches remain unchanged.

B. For STs

Contrary to the lecturers, the majority of the STs tended to prefer more teacher-guided-student-used technology within classrooms even when their comments were within constructivist approaches. That is, for deeper and longer lasting learning, for instance, educational programmes should be used by students rather than whole class demonstrations with the help and directions from the teacher. They raised the notions that, by doing so, students' active involvement and participation into activities would be accomplished. However, three of them also mentioned E&IT can be used in a context in which students can take full responsibility of their learning activities by means of various information sources, particularly the Internet:

> "By using technology in student-centred ways, it would be possible to have students who are able to question the information, thinking in a various ways and construct their own knowledge". (PT1, Int.)

> "E&IT can change the ways to teach and learn. Throughout our school life [primary and secondary] we have been contented with what our teachers provided to us. With the introduction of E&IT into education, now we can learn about whatever we want, in many cases we even do not need our teachers' help". (PT2, Int.)

> "In this new learning environment the student is active which is a plus for long lasting and deeper learning". (CT7, Int.)

> "Last year, I examined a CD [educational package programme]. It provides the necessary information first, including some games; enables you to repeat the subject, and then provides some questions to assess your progress. You, as a student, have the control and power over your learning". (BT1, Int.)

It is crucial to mention here that even though the STs believe that E&IT can create new learning environments for students through student-centred uses of technology, they also see the teacher as a main instrument who still provides the basic information of the

subject, on the one hand, and creates new opportunities for students' active participation, on the other. CT6, for instance, points out that:

> "I believe that E&IT has the potential to change this bad traditional teaching and learning. Having said this, sometimes we also need this approach [traditional teacher-centred]. Teachers should explain the subject as well". (CT6, Int.)

C. Observations

During observations (i.e. the observed lessons of L4 and L5), there was some evidence which illustrated that the use of technology and the participants' underpinning pedagogies were in a constructivist framework. However, the traditional teacher-centred approaches were dominant.

The current ways of incorporating E&IT and changing the teaching styles will be elaborated on later in the next section.

IMPLICATIONS AND CONCLUSION

As can be seen from Table 4 below, the participants' understanding of E&IT as an innovation in education and particularly in science teaching and learning were twofold. In some cases, however, the researcher presented some statements which were perceived as crucial even if few participants raised the issue in the data. E&IT enhances the current teaching and learning, and E&IT has the potential to change the current teaching and learning practices. Most of the summarised items in the table illustrate that the participants' understanding of using E&IT in science education were in a nature of cognitive-constructivist theory of teaching and learning. Data in Table 4 also revealed that the participants' beliefs about E&IT were very positive, yet their actual uses of E&IT in a format they perceived the appropriate use of E&IT were very limited. That is, their beliefs and understanding of the potential use of E&IT and their practices did not correlate with each other very much.

This supports the findings of many research reports (Dwyer et al. 1991; OTA, 1988/1995; Crawford, 2001; Ofsted, 2002; Altun, 2002; Lunenberg and Korthagen, 2003; Jakobsdottir, 2001; Schulz-Zander et al., 2002; Reid et al., 2003) and theoretical literature (Gros, 2002; Somekh, 2000; Gibson, 2001; Leach and Moon, 2000; Grabe and Grabe, 1998; Newton and Rogers, 2001; Pachler, 2001; Selinger, 2001) about the value of E&IT in education. However, as Fullan argues "educational change depends on what teachers think and do" (1991:107).

Table 4. *The Participants' understanding and perceptions of E&IT across data sources*

""Participants groups agreed in general with the idea presented.*

Summary across the data sources	Interview	Observation	Questionnaire
E&IT provides a new way of reaching vast amounts of information	*	*	*
E&IT provides a variety of information sources and promotes knowledge-construction, searching for information, questioning, analysing, summarising and sharing it with others	*	*	*
Presentations are more effective by means of E&IT methods	*	*	*
E&IT provides visual experiences for the learners; abstract to concrete	*		*

By means of simulations and related software it is possible to do experiments which are dangerous, too slow or fast	*		*
E&IT motivates the learner	*	*	*
E&IT helps the students with learning difficulties and slow learners, and promotes individualised-learning	*		*
E&IT saves teachers' and students' time and increases productivity	*		*
E&IT provides constructivist learning environments	*	*	*
E&IT promotes student-centred/led activities	*	*	*
E&IT promotes collaborative and cooperative learning	*	*	*
E&IT develops higher order thinking skills	*	*	*
E&IT promotes active learning	*	*	*

The participants' perceptions of E&IT mainly featured four roles for E&IT: (1) as facilitators; (2) as information sources; (3) as presentation tools; and (4) as a medium to change the nature of teaching and learning. This is summarised in Table 4 across different sources of data. The most commonly stated "added values" of E&IT in science education are presented in Table 4. Even though they were not many, some participants made their comments on the other beneficial uses of E&IT in educational settings such as tools for: professional development, communication tools, and administrative tools.

Data also suggest two aspects of the participants' understanding and perceptions of E&IT. The first one is that E&IT can enhance the ways the practitioners have done things. That is, E&IT have the potential to make the ways of teachers' current teaching and learning activities easier, quicker and more efficient. The second one was that E&IT has the potential to change things around; the ways to teach and learn, creating new learning environments and providing new pedagogical approaches to teaching and learning. The latter would change the roles of the teacher and learner and the traditional practices of teaching and learning. However, in both applications the added values of E&IT cannot be ignored. It is suggested that in order to secure benefits of using E&IT, and demonstrate the ways to teach in the information age, teacher education institutions should take these two aspects into account during training their prospective teachers in using E&IT in teaching and learning science. Teacher educators could be models for STs if they model the appropriate use of E&IT in real setting. This can be one of the effective ways in developing STs, giving them a clear and appropriate model of E&IT use in teaching science. More opportunities to practise with E&IT should be provided for STs in Faculty and practice schools to develop their technical and application skills.

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