Towards Effective Computer-Related Learning Environments for Primary School Students' Creative Thinking Development

Kampylis, P., Fokides, E., & Theodorakopoulou, M.

Abstract
In this paper, we report selected results of a survey on the use of ICT apparatus among Greek primary school students. The key findings reveal that personal computers play a significant role in students' everyday lives and that a gap exists between computer use in and outside school.
We point out the recent demand for a more creative primary education and we emphasize the creative dimension of ICT apparatus in general and personal computers in particular. We adopt the *creative cognition approach* that creativity can be taught, and even in its most remarkable forms utilizes ordinary cognitive processes.

We present the generations of computer-related learning environments and probe their correlations with learning theories. We also propose criteria for the evaluation and development of educational software and computer-related learning environments.
Finally, we propose the development and realization of constructivist virtual reality learning environments in primary education in order to bridge the gap between computer use in and outside school and to facilitate students' creative thinking and learning.

1.0 Introduction

Students nowadays grow up in a cultural environment which is increasingly shaped by technology, and particularly by Information and Communication Technologies [1]. Our survey in Greek primary schools on the use of Information and Communication Technologies (ICT) apparatus among students reveals that they play a significant role in children's everyday lives and that there is a growing gap between students' experience of computers in and outside schools.

2.0 The Survey

2.1 Literature Review

There are several surveys that support the argument that ICT apparatus in general and computers in particular, play a crucial role in primary school students' everyday lives. According to Sandford et al. [2] the 85% of British students play computer games outside classroom and the majority of British teachers and students support the idea of using games in formal curricular contexts; computer games play is regarded as motivating to students and improves their computer skills and general problem solving abilities. The survey also suggests that the main barriers perceived by teachers in the use of computer games are not those of the curriculum or of assessment, but the technical issues that need to be overcome.

Mumtaz [3] reports that students feel more satisfaction using computers at home than computers at school; the 85% of students enjoy playing computer games at the home computer while the 92% of them consider using of computers at school time-consuming and boring. He also states that there is a growing gap between computer experiences in home and school environments and that most of the average student's computer experience is gained from home use.

Fokides [4] affirms that 63.13% of Greek students from 4th, 5th and 6th grades (N=198) own at least one game console, 70.7% has access and uses a computer at home and only 11.11% does not use either of these devices at home. Computers are used mainly for playing games (86.4%), while various educational activities gather far less percentages. Students learn how to use computers from their parents (39.3%), from their brothers and sisters (26.4%) and by themselves (31.4%). Few children reported difficulties in learning how to use computers (5%).

Paraskevopoulos [5] asserts that the 55.9 % of Greek primary students (N=700) own a personal computer. The 96.4% of Greek students mention that there are computers in their schools but only 19.1% have access in them and just 14.7% use them for one hour per week.

Ilomäki and Rantanen [6] point out that the improvement of students' ICT expertise depends on strong internal motivation and in intensive use of ICT outside school. Hakkarainen et al. [7] stress that ICT-related activities make learning more meaningful and encourages students to make more efforts to study and that students use ICT significantly more intensively for recreational than educational purposes. They also point out that an important reason for the low intensity of ICT utilization in school settings is the fact that computers are usually located in a separate computer laboratory instead been in the classroom.

According to Wellington [8] the use of ICT at home is growing faster than its use at school and more research on ICT at home is needed. Similarly, Vruzas and Tsitouridou [9] hold the view that Greek homes are better equipped technologically than schools and students learn how to use a computer mainly by their older siblings or parents. They also report that one third of Greek primary school students (N=993) have a computer at home and it is used primarily for games.

2.2 Sample

The survey took place at eight Greek primary schools in the spring of 2005. The target group was 336 students from the 4th, 5th and 6th grades (table 1). The age range was 9-12 years old.

		Grade			
		4th	5th	6th	Total
Sex	Male	36	65	70	171
	Female	45	58	62	165
Total		81	123	132	336

Table 1. Participants in the survey

2.3 Research Tool and Data Gathering Procedure

A self-report questionnaire was designed to investigate Greek primary school students' attitudes to using ICT apparatus such as personal computers, game consoles and mobile phones. In this paper we only present selected data concerning the use of personal computers by students at home and at school. The questionnaires were administered by students' teachers and the participation in the study was voluntary.

2.4 Key Findings

Almost two out of three Greek primary school students (62.2%) have access to a personal computer at home and 77.2% have experience in using a personal computer. These findings are consistent with findings by similar studies in Greece [4,5]. They reveal a rapid grow in computer use at home by Greek primary school students during 2005, compared with the results of Vruzas and Tsitouridou [9] where almost one out of three students (30.7%) had a computer at home during 2000.

The 77.3% of students state that they learned to use the computer outside school mainly by their parents (39.7%), friends and relatives (18.6%) or tuition centers (14.9%). These findings are in line with those reported by other researchers [3, 4, 5, 6, 9] and reveal that most of the average student's computer expertise is gained from intensive use outside school.

Students report that they use computers at home mainly for playing games (87.4%). This type of computer usage is confirmed by several studies in Greece [4, 5, 9] and worldwide [2, 3, 7, 10].

2.5 Discussion: The Gap Between Computer In and Outside School

According to our data, most of the Greek primary school students are owners and/or users of ICT apparatus such as personal computers but they learn about and use them mainly outside school.

This distinction between ICT-in- and ICT-outside-school has two dimensions, the quantitative and the qualitative ones. It is quantitative, because there are already more ICT apparatus in students' homes than in educational settings and their use outside schools is growing faster than their use at schools [3, 8]. On the other hand, it is qualitative, because students own more powerful, updated and contemporary ICT apparatus in their homes [3, 4]. Schools have tried to keep pace with technology but access is still limited [3, 5, 7, 11].

Moreover, we observe the paradox that formal primary education strives to teach students the basic ICT skills while many students are already experienced users. As a result, students with expertise in using ICT are forced into the position of novice learner within the school environment [12].

Downes [13] states that students conceive of and use the computer as both a toy and a playable tool. As educators and parents who interact with students in every-day life we observe that they spend a lot of their free time playing computer games while in school settings they use computers for less edutainment activities such as word processing. These observations are supported by several surveys and empirical studies [2, 3, 4, 5, 7, 14]. Furthermore, several studies [3, 4, 5, 11, 13] report that students spend more time using personal computers in their homes than in their schools.

Consequently, we can argue that "*school use of ICT is just the tip of the iceberg - we need to explore the other nine-tenths*" [8] and that a gap exists between computer-in-school and computer-outside-school in terms of frequency of use, type of software and hardware, and style of interaction. This gap is confirmed by several studies in Greece [4, 5, 9] as well as in other countries [3, 6, 7, 13].

In any case, the gap between computer-in-school and computer-outside-school should be neither overestimated nor ignored. Further research is needed in order to better understand how students perceive and experience the use of computer-in- and computer-outside-school and then to explore the implications of these perceptions and experiences for education. The internal motivation, the meaningful activities, and the exploratory learning that characterize computer-outside-school should be utilized by primary education in order to achieve one of its main targets, students' creative thinking development.

3.0 Creativity and ICT

Recently, in an increasing number of policy documents and initiatives [e.g. 1, 15, 16] the role that creativity plays in education has been acknowledged as fundamental. Creativity is regarded as an innate potential in all people and as a crucial ability to response to problems across all subjects in the curriculum and across the challenges of everyday life [1, 17, 18].

However, when we refer to creativity in educational context it is important to define it. The authors of this paper adopt the definition of creativity as "*imaginative activity fashioned so as to produce outcomes that are both original and of value*" [1] because explicitly specifies five fundamental characteristics of creativity: imagination, process, purpose, originality and value.

The (British) National Advisory Committee on Creative and Cultural Education [1] made also an explicit distinction between the *elite* and the *democratic* creativity. Elliott [19] had identified the same types of creativity, which he called the *traditional* and the *new* one, while Craft [17] called them as *Big C Creativity* and *little c creativity*. The traditional, or elite or Big C creativity is ascribed to few, charismatic people who contribute to a field and whose contributions are recognised by the society. This type of creativity, stresses the value of the creative product and it has no significance in the school milieu. In contrast, the new, democratic, little c creativity is regarded as an innate potential in all students, regardless of their academic attainment, and could be widely applied in the primary education.

According to the *creative cognition approach*, the difference between elite and democratic creativity is one of degree rather than of type and human creativity, even in its most remarkable forms, utilizes ordinary cognitive processes [20]. Therefore, educators can facilitate students' creative expression, although motivation, culture, and other factors play a crucial role to human creativity.

In recent years ICT offer opportunities for new ways of creative expression. ICT provide new tools, media and environments which can be chosen and -when they are appropriate- contribute to the creative process [21]. By using ICT, students have the opportunity to be creators and collaborators -not just collectors and consumers- of information [22]. Although there is a growing interest and relevant literature [1, 17, 21, 23], the creative opportunities presented by ICT in general and computers in particular, have not been sufficiently recognised. Loveless [24] noted that it is not the access to ICT that sets creativity free, but the opportunities such access gives for active demonstration of imagination, production, purpose, originality and value.

Furthermore, the utilization of ICT apparatus by primary school students -in and mainly outside school- transform the ways they learn, lead to a multiplication of settings in which learning can be facilitated and provide new tools to support learning [17]. Many students have now the opportunity to be engaged in creative experiences with ICT outside school which are not widely reflected or developed in their ICT experiences at school; they have the means to externalise, share, develop and refine their thoughts, ideas and inspirations in ways that could not be done with the traditional tools [21].

ICT facilitate students' creative thinking when they offer to them problem solving and decision making activities, and help them to transfer knowledge in higher-order skills [25]. In addition, ICT makes most effective contribution in educational process when it is integrated with hands-on activities and other resources in a playful, non-deterministic approach [4, 13, 23].

Up to now, ICT realization in Greek primary education has not radically altered classroom activity; they are typically used to add to existing practices rather than replace them. Formal education uses ICT in order to enhance teaching but rarely to transform it [8]. We believe that we shouldn't try just to insert new tools to old practices. On the contrary, a *new educational culture* should emerge rather than a new educational technology [26]. Consequently, we might find ourselves asking "what kind of computer-related learning environments do we need to facilitate students' creative thinking?" and in general "do students learn more efficiently through computer-related learning environments?".

4.0 Learning Factors and Learning Principles

Regardless of the way that we view the learning process, four main factors that participate in it can be identified. These are [4]:

1. *Theoretical basis*, which consists of the main principles of a learning theory.
2. *Means of implementation* that include educators and tools such as printed material, teaching aids, computers, etc.
3. *Students* that are the target group of every educational system.
4. *External factors* such as the social milieu (other students, friends, parents, relatives, and so forth), the environment (school, geographic region and climatic conditions), the period during which the educational process takes place and also political and economical conditions.

The complex relations between the above factors, their interdependences, as well as the many variables that can influence them, render learning to a complex and exceptionally delicate process. There are many and contradictory theories that attempt to describe learning which leads us to believe that there is not only one theory which perfectly describes it [27]. Yet, no one can doubt that students obtain -up to a certain degree- knowledge and skills that they -or others- consider important. In an attempt to interpret this oxymoron, we can formulate three basic principles of learning:

- *Learning is an individual phenomenon.* Each individual learns in his own way and interprets the surrounding world differently; therefore, there is not a single "right" representation of knowledge. This view stems from Piaget's work [28, 29, 30].
- *Learning is a social phenomenon*. This principle originates from Vygotsky's work [31, 32]. An individual learns because it is essential for his/her existence to learn. However, an individual is subject to unavoidable external influences in the context of society.
- *The principle of uncertainty.* The learning factors described in previous paragraphs are subjects to an extremely large -almost infinite- number of variables endogenous as well as exogenous. Since we learn for the whole span of our lives, these variables change -and keep changing- dynamically. This renders impossible to accurately determine all the variables, their weightiness and their exact influence in the learning process even for a single person. Hence, it is quite safe to proclaim that all learning theories are imperfect and incapable of fully describing exactly how we learn [33].

Due to the principle of uncertainty the following stand:

- Learning is a dynamic process. It occurs randomly and unpredictably at any place and at any time.
- Learning objectives can and must be altered -partially or totally- in order to correspond with how knowledge acquisition is progressing.
- Learning outcomes are not predictable and certainly not pre-determined.

All teaching methodologies ought to take advantage of every situation and to transmute it in a learning opportunity. They also have to be flexible enough in order to adapt to the needs of a person or a group of persons. Unfortunately, with traditional teaching students learn by assimilating, as they listen to the teacher develop a subject, and by using textbooks. This teaching approach aims at mediating so that the student acquires a predetermined attitude or portion of knowledge. Correspondingly, the evaluation, isolated at large from the learning procedure, is done in order to check whether the students acquired the offered knowledge. The modern educational thought however, stresses the importance of students' active participation. Students become more capable of acquiring, keeping and generalizing new knowledge when they participate actively in the construction of this knowledge, in a "do-and-learn" process [34].

It is worth analyzing this assertion. First of all we have to indicate the value of an experience. The experience with which an idea/a portion of knowledge is associated, is important for the comprehension of the idea/the portion of knowledge as much as for the use of it [35]. The experience is the "vehicle" for the construction of knowledge. Secondly, we have to portray the role of symbols. By the term "symbol" we mean the oral and written signs (language, letters and numbers) we use in order to communicate with each other. Cognitive theories in general perceive human brain as a computer whose basic operation is the intellectual handling of symbols [36, 37]. Knowledge is nothing more than the efficient handling of symbols. The problem with this cognitive view is that it does not completely explain all the logical processes, nor the way we handle situations where there is no use of symbols.

As Winn [38] points out, we get to know the world in two ways, from first person and third person experiences. The former are derived from the everyday contact with the surrounding world, they are direct, personal and subjective, in a way "silent" because we do not realize we have learnt something and they do not require the use of any symbols. The latter are derived from someone else's descriptions, they are indirect, explicit and we always realize that we have learnt something because they have taught us. The use of symbols is necessary in order to become possible the communication between the person that explains and the person that learns. For example, first person experiences are what we feel and think when we watch a film. We have third person experiences when someone else explains to us the plot of the film, what the actors did and so on.

A second important element that emerges from the above film paradigm is that first person experiences are more "whole" than their counterpart. Too much meaning, too much useful data is lost when a third party tries to communicate to us complex ideas, concepts or situations. It is much better "seeing something with your own eyes", than having a faint/incomplete description of it. First person experiences give the opportunity to the learner to instinctively apprehend an idea/a portion of knowledge, without the use of symbolic representations.

Computers offer third person experiences mainly because information contained in them reflect the ideas/point of view/opinion of someone else -namely the developer's- and is not directly accessible, but through the interface. In essence, the interface is the means of communication between the computer and the user through the operating system, programmes, input and output devices. All these devices and programmes use sets of symbols other than the ordinary ones. For example, left, right and double click and drag-and-drop are the symbols used by the mouse, each of them having specific uses. So, there are two layers of symbols between the user and the computer, making the process of knowledge acquisition a little bit more intricate.

The ideal would be to remove the second layer of symbols imposed by programmes and devices, so that the bilateral man-machine communication to be conducted in a more "natural" way, like the way we interact with the real environment. By doing so, the interface can become almost invisible and the user can have experiences that are closer to real ones.

4.1 Learning Theories and Educational Computer Applications

The first educational computer applications materialized behaviouristic perceptions and concentrated in content. They analyzed the knowledge and the dexterities that should be acquired by students in individual constitutive elements, where comprehension of these in total, led to the expected behaviour. Characteristic example of this view was Computer Assisted Instruction (CAI), which had the form of "drill and practice", with the trainee having a minimal control of what he learned. Everything was predetermined from the designer, even though in some cases the trainee/user was given the opportunity to omit certain subjects [39].

In the second generation there was a change from the emphasis on the content, to the emphasis on the way that the content is presented to students. This resulted from the idea that the process with which students process information can be more important than the information itself. Cognitive theories offered the essential theoretical support to the designers of educational applications. Characteristic example of this generation is applications that are programmed in such a way that they appear to "think" and answer "intelligently" to students' data entry. However, the objective remained the same: the conveyance of knowledge to the trainee in the best possible way [40]. In both cases the designer breaks down the cognitive material in small pieces. In the behaviouristic approach the goal is to achieve the desired behaviour and in the cognitive approach the goal is the transition from simple concepts to complex ones.

Constructivism provides the theoretical background in the third generation of educational use of computers. The change in the design of applications is significant because constructivism does not face learning in an objectivistic way, supports that predetermined and foreseeable results do not exist and considers that teaching should encourage and not guide the learner. Jonassen [41] mentions the characteristics that instructive planning must have according to constuctivism:

- Provide multiple representations of reality and to avoid simplifications, presenting the natural complexity of the world.
- Provide authentic tasks to students
- Provide instructive environments that support the study of real cases
- Knowledge is constructed in association with the frame and the content that is applied.
- Encourage practices that support reasoning.
- Support collaborative learning and not the competition between students.

Multimedia and hypermedia are the computer applications that satisfy to a large extent the above conditions and allow a non-linear course in teaching, giving students the opportunity to choose their own path. Thus they are extensively used for the materialization of constructivistic perceptions. However, there is the fear that students might be disorientated, "lost" in the maze of choices and hyperlinks. Therefore, many propose a combination of old and new instructive methods and a progressive increase of the control that the student has over the instructive process [e.g. 42, 43].

From this brief presentation of the first three generations, it is easy to realize their imperfections based on the principles of learning mentioned in the previous chapter. The first generation separates learning from its individualistic and social dimension, considering it as something independent. For that reason, it corresponds to none of the learning principles. The second generation gives emphasis to the individualistic aspect of learning. Also, it does not satisfy the principle of uncertainty, because student-computer interactions are to a large extent beforehand drawn, which means that learning is directed to specific channels. The third generation comes very close in satisfying all three principles of learning. However, the objections to the completely "open" planning deter the complete satisfaction of the principle of uncertainty. From this viewpoint, the process of learning is relatively limited.

Yet, there is a fourth generation of educational use of computers, which is heavily based on 3D-graphics and 3D-animation. This generation also materializes constructivistic ideas. However, according to Winn [38] this generation adds another element. Winn notes that in this type of applications the use of symbols is not essential. Computers in the first three generations offered "third person" experiences because:

i) the computer interferes between the individual and the information that it contains,
ii) this information emanates from somebody else; somebody has imported it to the computer,
iii) information is not immediately available, but via the interface, the screen, the mouse, the keyboard, that all use systems of symbols and
iv) these symbols require some thought from the user so that they can be used effectively.

Consequently, even if it is an important factor the way that information is presented (second generation) and even if it is an important factor the interaction with it (third generation), computers do not offer "first person" experiences, which as we already pointed out are important. Constructivism provides enough ideas on how this type of experiences can be acquired with the use of computers. Two are the main points that we focus our interest on [38]:

1. The interface must be absent; in a way, the computer should be invisible. This means that the user/student will have to use for his communication with the computer not the traditional appliances (mouse, keyboard, screen), but others that do not use symbols.

2. In applications the interaction between an individual and the computer or between individuals should not be predetermined, but all kinds of interaction must be possible.

Such environments that are found in virtual reality applications can satisfy all of the principles of learning. This is because:

i) they allow social interactions,

ii) since they use specially designed equipment, do not use symbols, which results in "first person" experiences and

iii) because of the open planning and the potential of free environment's exploration, interactions are not predetermined, the course of learning and its results are not predetermined (table 2).

As a result, learning in a virtual reality environment is a dynamic process determined from the user that places the objectives and alters them at will.

	Generation of educational computer applications			
	1st	2nd	3rd	4th
Theoretical background	Behaviorism	Cognitive theories	Constructivism	Constructivism
Student's role	Passive	Active		
Emphasis	Content	Interaction	Interaction	Interaction, Open design
"First person" experiences	No	No	No	Yes
"Third person" experiences	Yes	Yes	Yes	Yes
Use of symbols	Yes	Yes	Yes	Yes/no
Learning an individual phenomenon	No	Yes	Yes	Yes
Learning a social phenomenon	No	No	Yes	Yes
Principle of uncertainty	No	No	No	Yes
Indicative applications	Text, Educational games	Educational games	Multimedia, Hypermedia	Virtual reality

Table 2. Comparison of educational computer applications generations

5.0 Evaluation and development of computer-related learning environments.

Students benefit from meaningful and playful interactions with the computer -in and outside school- [44] and educators should utilize evaluated computer-related learning environments and computer games in the classroom when they promote exploratory learning, problem solving skills, thinking skills, memory, perseverance, imagination, collaboration and team work [3].

There are three basic advantages in the utilization of constructivist methods through computer-related learning environments in primary education:

- Constructivist computer-related learning environments offer knowledge situations that demand problem solving and decision making schemata
- The utilization of computer-related learning environments is compatible with average student's everyday life because he/she is already an intensive computer user mainly outside school.
- Computers can be seen as both a tool and a medium for students' higher order engagement in creative processes.

Virvou and Katsionis [14] state that students benefit more from an educational virtual reality game than the conventional educational software and Downes [10] asserts that children learn a number of skills and strategies from playing computer games. Evaluation is an essential and continuous element of the design and realization process of educational software in general and educational computer games in particular. The educational software should be tested by students and educators on real situations, redesigned if necessary and then tested again [45].

Our ongoing research project under the theoretical framework of creative cognition and constructivism aims to specify criteria for the evaluation and development of computer-related learning environments that facilitate students' creative thinking. These criteria include:

- The open design with no-predetermined, dynamic user-machine interactions
- The support of synchronous and asynchronous collaboration between users
- The almost invisible interface environment between machine and user
- The absence of symbols and an almost "real" environment
- The constructive and open-ended tasks and assessments
- The multimodal representations

6.0 Conclusive Remarks

According to our survey and literature review, students learn how to use computers mainly outside school and through exploratory learning by *trial and error* and *learning by doing*. This type of effective learning contrasts strongly with the dominant pedagogical approaches in Greek primary schools that continue to separate learning and doing. These different approaches produce tensions where educators employ computers within traditional pedagogical frameworks, and when students realize that their effective learning strategies are discounted within the classroom. Furthermore, as students become intensive ICT users in their homes developing skills and predispositions, the gap between learning at home and learning at school becomes wider. Pedagogy that reflects a convergence between learning in and outside school should take into account that students consider computers as *playable machines* [10, 13] and they learn effectively when they learn by doing.

The increasing effect of ICT apparatus in general and computers in particular into students' everyday lives provokes many questions that necessitate further research: What are the implications for primary education of ICT use at home by students? How can we utilize the successful use of computers outside school for learning in the classroom? How could primary education bridge the gap between ICT in and ICT outside school? How should primary education bridge the gap between the students who use ICT at home and those who do not? What type of training do educators need in order to utilize the opportunities offered by ICT in home? What are the evaluation criteria for the pedagogical utilization of computer games? What are the long-term results of ICT usage at home and at school in students' learning? What kind of computer-related learning environments do we need in order to facilitate students' learning?

We strongly believe that computer-related learning environments may offer to students meaningful, edutainment activities that liberate their creative potential and enhance learning. In any case, as Piaget in Jervis & Tobier [46] states "*the principal goal of education is to create people who are capable of doing new things, not simply repeating what other generations have done - people who are creative, inventive discoverers, who can be critical and verify, and not accept, everything they are offered*".

7.0 References

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Towards Effective Computer-Related Learning Environments for Primary School Students' Creative Thinking Development

Panagiotis Kampylis[1], Emmanuel Fokides[2], Maria Theodorakopoulou[3]

[1]Department of Computer Science and Information Systems,
University of Jyväskylä,
Agora Center, P.O.Box 35, FI-40014, Jyväskylä, Finland
pakampyl@jyu.fi

[2] Department of Primary Education
Aegean University,
1 Dimokratias str, 85100 Rhodes, Greece
fokides@aegean.gr

[3] Athens College,
Kantza Attikis, 153 51 Kantza, Greece
theoma@gmail.com

Abstract

In this paper, we report selected results of a survey on the use of ICT apparatus among Greek primary school students. The key findings reveal that personal computers play a significant role in students' everyday lives and that a gap exists between computer use in and out of school.

Based on this data, we point out the recent demand for a more creative primary education, and we emphasize the creative dimension of ICT apparatus in general and personal computers in particular. We adopt the *creative cognition approach* which declares that creativity utilizes ordinary cognitive processes - even in its most remarkable forms - and that it can be taught.

In addition, we present the generations of computer-related learning environments and probe their correlations with learning theories as well as teaching and learning process improvement. Moreover, we suggest criteria for the evaluation and development of educational software and computer-related learning environments.

Finally, we propose the development and realization of constructivist virtual reality learning environments in primary education in order to bridge the gap between computer use in and out of school, to facilitate students' creative thinking and learning, and to enhance accessibility and availability of learning resources.