The Use of Educational Scenarios Using State-of-the-art IT Technologies such as Ubiquitous Computing, Mobile Computing and the Internet of Things as an Incentive to Choose a Scientific Career

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Abstract.

By definition, technology seeks to exploit scientific knowledge in order to serve today's practical human needs. The promotion of IT-related technologies such as Ubiquitous Computing, Mobile Computing and the Internet of Things (UMI) is a matter of great concern to the scientific community due to their diffusion in all areas of human activities. The educational community recognizes the above technologies as a tool that can be used to improve the quality and effectiveness of the education, while, at the same time, is facing the challenge to highlight ways to utilize the technical characteristics of UMI technologies in order to lead to learning, not just the information accessibility. The presented research contains a proposal for the exploitation of innovative technologies in the field of education and presents the results of its implementation. More specifically, it is a proposal to use UMI technologies in the field of formal Secondary Education based on educational scenarios. Additionally, it is investigated if using UMI while teaching the 15-17-year-old students provides learning- not only ubiquitous access to information- and if it serves as a motivator for choosing a career in science and technology.

Keywords: Ubiquitous Computing/Mobile Computing/Internet of Things (UMI), Computational Thinking, carrier

1   Purpose

The relationship between technology and education has emerged around the 1950s. In particular, developments in computer technology have led researchers to address technology as an active student partner in order to build knowledge [14] and thus improve the quality and effectiveness of the training provided. The advocates of the use of computers and their associated technologies as a way to address educational needs and problems claim that the aforementioned support student motivation and facilitate collaborative learning, participatory intelligence and problem solving [22].

The justification for this research is based on the following observations:

- The modest level of education in the IT course, which is supported by educators internationally. In particular, the report "Running On Empty : The failure to teach K-12 computer science in the digital age" describes the situation in USA [28]. Similarly, the report "Shut down or restart: The way forward for computing in UK schools" [23] depicts the problem in UK. In Greece, although there are no specific surveys, the findings are derived from the pupils' results in the PISA competition [21] and the statistics from the Ministry of Education, Research and Religious Affairs on the performance of students in the respective lesson "Development of Applied Applications in a Programming Environment" of the Pan-Hellenic Examinations [18].
- The need – especially as far as the young people are concerned- to acquire knowledge and cultivate skills and attitudes related to UMI technologies that will lead them to understand the real world (physical and digital), to strengthen their digital profiles and, eventually, to be activated to participate in socio-economic processes [3].
- The cultivation of Horizontal Computational Thinking skill. In order to accomplish this goal, educational researchers have proposed integrating Computational Thinking culture into curricula [29]. In fact, many countries (Russia, South Africa, New Zealand, Australia, Great Britain, etc.) aim to cultivate Algorithmic Thinking through programming [12]. According to the research conducted by the Joint Research Center (JRC) of the European Commission's Science and Knowledge Service [1], other approaches suggest the cultivation of Logical Thinking and/or Problem Solving. In Greece, Computational Thinking is not directly involved in the curricula [26].
- The favorable conditions for job creation in the area [4, 13]. Specially, raising students' interest in technology and their self-confidence in using it may affect their decision to pursue a future career in the field.
- The advantages and the reservations that have been made regarding the use of innovative IT technologies in education. The advantages include integration of educational activities in everyday life [11], ubiquitous access to digital resources [17], students' interest in mobile devices [15], customized training for trainees' needs [27], support for collaboration [11], learning in a playful way [25], making inquiry about the educational process [6] and exploiting the potential of mobile cloud

computing [10]. Reservations concern the possibility of creating or widening the digital gap between students who have and those who do not have access to innovative technologies [8], pointing out that access to information does not necessarily mean learning [24], the necessity for pedagogical documentation of the educational process [16] and issues concerning the security of data and privacy of communications [19].

It has, therefore, been investigated whether the exposure of students of formal secondary education to UMI technologies during the teaching of "Informatics Applications" in the 1st grade of General Lyceum has an impact to the cultivation of Computational Thinking, increases the students' interest in technology and affects their self-confidence in the use of technology and their interest for a future career in technology and science.

2   Approach

An educational action research was designed and implemented.

The action research was chosen as the most appropriate type of research since the aim was to intervene in an existing system (school) in order to address a specific problem (level of Computational Thinking) for the benefit of the participants (students and teachers) and to examine the impacts of such an intervene [7]. Design, action, observation and reflection – the four phases proposed for this type of research were implemented (Kemmis & McTaggart, 1992). A calendar was kept by the teacher throughout the action.

2.1   Design

The research concerned teaching the course "Informatics Applications" in the First Class of General Lyceum. The curriculum and teaching instructions indirectly aim at cultivating Computational Thinking through the creation of small-scale applications.

The chosen hardware was the Arduino microcontroller and the UDOO NEO and Raspberry Pi single-board computers. These three platforms enable the development of independent interactive objects while at the same time they are credible, have good documentation, and educational targeting.

Two questionnaires were created during the planning of the action. The first one (Pre-test) was answered by the students before the action and the second one (Post-test) after it. The questionnaires traced students' attitudes towards problems and technology, their ability to solve problems, the knowledge of the terms and principles related to the operation of innovative IT technologies as well as students' interest and self-confidence in using technology and their intention to pursue a career in technology and science in the future.

Still, two educational scenarios were designed. The first concerned the introduction of students to the basic terms and principles of the operation of innovative IT technologies and their platforms. The second concerned the teaching of the conditional statement by developing a simple application on the three selected platforms. The conditional statement was chosen as it is a source of great difficulty for novice developers. Many of the difficulties are due to misunderstandings as far as the definition and manipulation of variables are concerned [20]. Elements of Social Constructivism, Activity Theory and Distributed Cognition were exploited. In particular, the Interest-Driven Creator Theory [5] has been adopted to claim that trainees are transformed into creators when a field is of interest to them and provided with appropriate technology support. Indeed, the selected framework includes a recurring cycle of events that trigger, amplify and expand trainees' interest [30]. Additionally, the Computational Thinking Development Framework proposed by Brennan & Resnick was adopted and adapted according to the needs of our research [2]. The suggested activities by the educational scenarios were student-centered and cooperative.

Finally, the calendar structure was selected. It included the fields: Action (Action Description), Start / End (Start Date and Expiration Date), Duration (Required time), Equipment (Required equipment), Tasks (Detailed description of tasks) and Observations.

2.2 Action

Fig. 1. "Introductory Scenario - Single board microcontrollers and computers – Internet of Things" – Preparing presentation.
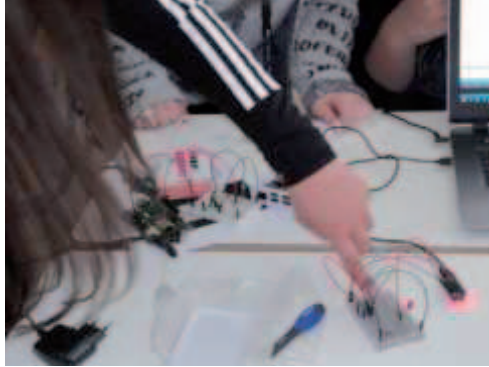
Fig. 2. "Conditional Statement Scenario – Creating applications" – The application.

Fig. 3. "Conditional Statement Scenario – Creating applications" - Assessment process.

The implementation was completed in four phases: completion of the Pre-test (45 min.), implementation of the educational scenario "Introductory Scenario - Single board microcontrollers and computers – Internet of Things" (4 hours) (see Fig. 1), implementation of the educational scenario "Conditional Statement Scenario – Creating applications" (4 hours) (see Fig. 2 & Fig. 3), and completion of the Post-test (30 min.).

2.3 Observation

The observation is based on the comparison of the students' answers to Pre-test and Post-test and on the entries of the teacher's calendar.

2.4 Reflection

Reflection includes commenting on results, comparing with expected results, recording research constraints, and proposing new research issues.

One teacher and thirty-eight students participated in the event. The action took place between February 2017 and April 2017.

3   Outcomes

As already mentioned, the two questionnaires and the calendar completed by the teacher were used as criteria for the effectiveness of the action. The findings of the survey were positive and confirmed the expected results.

In particular, from the responses to the two questionnaires the following facts were observed:

- *Students' attitudes towards problems*: Before the action, students recognized the problems as part of their daily routine, but they found it difficult to formulate problems that did not belong to STEM and did not apply some phases (decomposition, pattern recognition). After the action, students said they persist in understanding a problem to a moderate degree, they analyze problems to their components, prefer to solve problems inspired by the real world, and feel modestly confident when solving complex problems.
- *Students' technology attitude (Post-action)*: Students declared a very positive attitude towards technology. They stated that computers offer learning opportunities, recognized the importance of use skills, and said they enjoy dealing with computers.
- *Students' view of the action*: The students expressed their positive experience of the action. They stated that the action increased their interest and self-confidence in using technology and resolved their questions about the applications of technology in real life.
- *Problem solving*: Before the action students were able to solve simple problems but their performance was moderate in solving complex problems and their Algorithmic Thinking was too weak. After the action, the students applied the problem solving procedures to a satisfactory degree, demonstrated good performance in solving complex problems and improved the level of their Algorithmic Thinking.
- *Terms and Principles of UMI Technology*: Prior to the action, a few students were aware of the term Internet of Things without, however, being aware of the precise meaning of the term and the principles of operation of innovative IT technologies. After the action, students were able to use the terms and prepare short technical texts to describe the UMI technology services.
- *Intention for a Future Career*: Prior to the action, students were highly interested in pursuing a career in science and technology. Following the action, the respective percentages have increased further.

From the calendar entries, the following facts were noted:

- *Design phase*: This phase lasted a total of 150 hours. The process of creating the Pre-test and the Post-test was interesting. The creating process of the "Introductory

Scenario - Single board microcontrollers and computers – Internet of Things" was demanding, especially for a teacher without prior experience in UMI technology. The creation process of the "Conditional Statement Scenario – Creating applications" was very demanding. Compatibility problems between Arduino and Windows 10 were identified, while UDOO NEO had unstable behavior.

- *Action Phase*: No problems were encountered when Pre-test and Post-test were completed. The two educational scenarios were implemented as planned. The students participated in the activities with enthusiasm and achieved the evaluation procedures. Students had difficulty in understanding technical texts in English, cooperating, reading and selecting material from various sources, and programming with Python and Wiring.

4   Conclusions/Recommendations

The questioning of the quality and the results of the provided education in Informatics and, more generally, in the cultivation of students' Computational Thinking, combined with the broad incorporation of innovative IT technologies (Ubiquitous Computing / Mobile Computing / Internet of Objects) in all activities of modern societies and the opportunities offered for scientific career have prompted international organizations and researchers to find ways to increase students' interest in technology.

The action research presented here consists a proposal for the educational use of UMI technologies in the context of formal Secondary Education when teaching Computer Science in 15-17 year-olds. The proposal concerns the mapping of the results of the implementation of two educational scenarios through two specially constructed questionnaires and the calendar entries that were kept by the teacher during the action.

The findings of the research were encouraging as far as knowledge and skills attitudes and at the level of attitudes and future career choices are concerned.

In particular, the ability to implement problem-solving procedures has been positively affected to a satisfactory extent by the intervention. In addition, the ability to express a solution of a problem in algorithms has been positively affected to a great extent. Indeed, students understood difficult concepts such as variables and logical expressions and wrote or modified conditional statements.

On the contrary, student's attitude towards problems was not significantly influenced by the action.

A positive attitude of students towards technology was recorded. The students declared their interest, self-confidence and understanding of the environment increased due to the intervention.

The action has had a positive impact on the understanding and ability to use terms of state-of-the-art IT technologies.

According to students' answers their interest in pursuing a career in science and technology was effected positively by the intervention.

The limitations of research include: (i) limited access to hardware, with the result that students work in groups of 6-7, (ii) the short duration of the action, and (iii) the small sample and the absence of a test group which makes it impossible to draw generalized conclusions.

In the future, it would be useful to deepen on electronic circuits by creating new educational scenarios. Thus, students will acquire the appropriate knowledge to design electronic circuits in order to achieve specific functions or to modify existing plans in order to change their function. This would increase their interest and self-confidence in using technology and could also work as an adjunct to teaching other subjects (Physics).

It would also be interesting to explore the impact of the cross-thematic approach with the use of innovative IT technologies both at the level of school performance and at the level of attitude towards technology.

A research on the contribution of developing intelligent object applications, in the context of computer science courses, aiming the cultivation of students' computational thinking is an interesting proposition. Such an action, however, requires a longer duration of the action as well as and access to additional equipment.

Finally, the implementation of similar actions on a larger scale could yield more, editable by quantitative methods of analysis, data. Furthermore, the use of a test group, so as to have a base of comparison, could be very useful

The findings of the action research are consistent with in the findings of the Technology Acceptance Model, according to which IT users are positive about new technology when they are convinced of its usefulness and its potentials [9].

5   Acknowledgment

6 References

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