# COMPUTER SCIENCE TEACHERS' REAL PRACTICES: A CASE STUDY

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**Abstract**

This paper focuses on the approaches used by Computer Science (CS) teachers to teach CS concepts at the higher level of secondary education and especially in Grades 10-12. It is based on a case study where twenty five CS teachers in Greece were observed teaching CS concepts in the classroom. The focus of the observation was on a variety of specific teacher interventions such as: a) how students' previous knowledge was investigated and how this knowledge was connected with the new learning concepts in focus, b) the kind of activities proposed by the teacher, c) the kind of communication taking place, d) how the students' mistakes were handled, e) how many students were involved in each lesson, f) the kind of motivation used to involve students in each specific teaching session, g) the learning media used and h) summary and abstraction of the main learning aspects of each lesson. Based on these data, 7 specific CS teaching profiles were formed.

## Introduction

Computer Science (CS) has been proposed for integration as a learning subject in primary and secondary education in response to the pressing need to provide academic coherence for the rapid growth of computing and technology in the modern world, alongside the need for an educated public that can utilize technology for effective citizenship in the 21st century (ACM, 2003). For the teaching and learning of the variety of cognitive and technical aspects related to CS, traditional learning theories (Skinner, 1968) emphasize the good presentation of the aspects in focus using the telling-and-asking approach, drill and practice, textbook activities, the authoritarian role of the teacher and the passive role of the learner. In contrast to these traditional theories, modern social and constructivist theories of learning emphasize the active, subjective, constructive and social character of knowledge construction (von Glasersfeld, 1990; Vygotsky, 1978). These modern theories of learning have been widely adopted by a number of researchers in CS Education. Taking into account these modern learning theories and epistemological issues regarding CS, a variety of teaching approaches were used, with very illuminative positive learning results. Such teaching approaches emphasize learning activities that provide learners with opportunities for exploration, cooperation, problem-solving, project work, role-playing, concept-mapping, and collecting data from rich resources of information (Abernethy, Gabbert & Treu, 1998; Ausubel, Novak & Hanesian, 1968; Gray, Boyle and Smith, 1988; Hadjerrouit, 1998; Hagan and Sheard, 1988; Kordaki, 2001; Lawson, Abraham & Renner, 1989; Lee and Philips, 1988).

The adaptation of such modern teaching approaches by CS teachers to their everyday school practices is crucial; their plans and decisions significantly affect what and how each subject is taught and, consequently, what is to be learned by the students (Hargreaves, 2002). Thus, it is essential to investigate teachers' everyday teaching approaches in order to improve the design of appropriate teacher education programs. Despite this fact, studies investigating CS teachers' real teaching practices in the secondary level of education, and in

particular in Grades 10-12, have not yet been reported. The aim of this study is to investigate CS teachers' real practices within a classroom context.

In the next section of this paper, the context of this study is presented, followed by CS teachers' teaching practices and a discussion in terms of the teaching approaches used. Finally, conclusions are drawn.

## The context of the study

This paper is part of a wider study aiming to investigate high school CS teachers' views regarding the basic components of an appropriate CS curriculum for students in Grades 10-12 (Kordaki and Kalyva, 2006) as well as the relationship between those teachers' conceptions regarding teaching and learning CS and their real teaching practices. Relationships between teachers' conceptions, practices, undergraduate studies and gender are also investigated. In this paper, we focus on CS teachers' teaching approaches used in their everyday secondary level school practice and especially while teaching CS concepts in Grades 10-12. In terms of methodology, this study is a case study (Cohen & Manion, 1989) where twenty five CS teachers (12 females and 13 males) in Greece were observed while they taught their students CS concepts. The data collected through observation sheets includes a variety of specific points referring to the teacher interventions performed during each lesson. More specifically, the data collected referred to specific teacher interventions in terms of: a) how students' previous knowledge was investigated and how this knowledge was connected with the new learning concepts in focus, b) the kind of activities proposed, c) the kind of communication taking place, d) how the students' mistakes were handled, e) how many students were involved in each lesson, f) the kind of motivation used to involve students in each specific lesson, g) the learning media used and h) summary and abstraction of the main learning aspects of each lesson.

## Results and Discussion

The data related to the CS teachers' practices collected during this experimental study are presented in Table I. The first column presents the individual teachers (Ti) participating in this study. The gender (F=female, M=male) and the undergraduate CS degree (C= CS College, U=CS University Dept., E=CS and Engineering University Dept) of these teachers are presented in Columns 2 and 3 correspondingly. CS teachers' practices are presented in Table I in terms of the following characteristics: a) the kind of media used (Column 4), b) the kind of activities performed (Column, 5), c) the kind of communication taking place (Column, 6), d) how students' mistakes were handled (Column, 7), e) the kind of motivation used (Column, 8), and f) the number of students involved (Column, 9). In the last column (Column 10) CS teachers are classified in specific teacher-profiles taking into account all the previous data.

*Media used:* Most teachers (15 teachers) used the traditional media limited to the use of chalk and black-board (BC). Few teachers (4 teachers) used video-projector (VP) and work sheets (WS) while only two teachers proposed the use of the Internet (I) as a learning medium.

*Learning activities:* i) *Project work* (PW) was used by 6 teachers. Main examples of PW observed were: preparation of a power point presentation, a task demanding data processing using some functions included in EXCEL, editing a report. ii) *Free Browsing* (FB): students were encouraged to engage in free browsing via the Internet. Despite the Internet being a rich source of information and a number of teaching approaches exploiting its advantages having been

reported, this was not observed in CS specific teaching practices during this experiment; there were no learning aims as unguided students engaged in free browsing. This approach was used by 2 teachers. iii) Textbook *drill and practice activities* appropriate to prepare students to *pass the national exams* (NE) in order to enter a CS School were used (by 9 teachers). iv) *Reading and Commending* Text (RCT) and power point Slides (RCS) was used as a teaching approach by 5 teachers. v) One teacher presented information regarding the learning subject in focus and weakly negotiated its aspects using *Whole Class Discussion* (WCD). vi) Finally, one teacher involved her students in answering questions and solving *Problems* demanding *Critical Thinking* (PCT). It is worth mentioning that some teachers (4 teachers) *reduced the teaching time* (rt) set by the school program; they quickly taught the section designated in the national CS curricula and then left their students free to play in the schoolyard.

Table1. Basic characteristics of CS teachers' real teaching practices

| CST | Gender | Undergr aduate Degree | Media used | Learning activities | Commu nication | Handling student mistakes | Motives | Student involve-ment | Teacher profiles |
|---|---|---|---|---|---|---|---|---|---|
| T1 | M | C | BC | NE | M-IS | TI | NE | Few | P1 |
| T2 | M | E | BC | NE | M-IS-D | SR | NE | Most | P2 |
| T3 | F | Physics | BC | PW | C | T | PW-E | All | P6 |
| T4 | M | Math | BC+VP | NE | M-IS-D | SR | H, LG, NE,VP | Most | P2 |
| T5 | F | U | BC | NE rt | M-IS | TI | NE | None | P1 |
| T6 | M | C | BC | RC | M | - | Tests | None | P3 |
| T7 | F | Math | BC+WS | PCT | C | SR | H, Q, EF | All | P7 |
| T8 | M | E | BC | RCrt | M | T | None | None | P3 |
| T9 | F | U | Lab | NE rt | S | TI | None | None | P1 |
| T10 | F | Math | BC | NE | S | - | Q | Few-boring | P1 |
| T11 | M | E | BC+WS | NE | M | TI | EF, NE | None | P1 |
| T12 | F | Math | WS | PW | C | SR | PW-LG | All but bored | P6 |
| T13 | M | U | VP | RCS | M | - | H | Bored | P3 |
| T14 | M | Physics | VP | RCSrt | M | - | None | Few | P3 |
| T15 | M | Physics | - | WCD | WCD | TI | Q | Half | P4 |
| T16 | F | U | BC | RC | C | SR | Q | Few | P3 |
| T17 | M | U | I | FB | PC | - | FB | All | P5 |
| T18 | F | Math | BC | NE | IS | T | Q | Most-boring | P1 |
| T19 | F | Math | BC | NE | M-IS | TI | LG | Few | P1 |
| T20 | M | E | VP | PW | C | SR | PW | All | P6 |
| T21 | F | Math | BC | PW | C | TI | PW | All | P6 |
| T22 | M | E | I | FB | PC | - | FB | All | P5 |
| T23 | F | Math | BC | NE | M | - | Q | Few- boring | P1 |
| T24 | F | E | - | PW | C | TI | LG | All but bored | P6 |
| T25 | M | U | WS | PW | C | | PW | Most | P6 |

*Communication:* The kinds of communication observed were as follows: a) Communication (C) between the groups while performing project work was observed as well as dialogue (D) between the students and their teachers. b) *Monologue* (M) also dominated most teachers' practices. In most cases this monologue took the form of direct *Instruction of a Student* (IS) to solve a problem on the black-board. c) When students engaged in free browsing, unrelated, informal Personal Communication (PC) relating to their personal interests was observed. d) Whole Class Discussions (WCD) were also observed when a specific learning subject was verbally presented to the students and was not combined with the assignment of specific tasks. i) Finally, *Silence* (S) was observed when students transferred Ready Programs into their computers and ran them.

*Handling student mistakes:* CS teachers handled their students' mistakes by: i) Labeling and directly correcting the mistake through *addressing* the *Individual*

student involved (TI). ii) Directly correcting the mistake *in front of the class but avoiding addressing the individual* student involved (T). iii) Asking the individual Students to Reflect (SR) on their opinions and corrective action.

*Motivation:* Project work (PW) motivated students to be actively involved in their learning processes. Free browsing (FB) also motivated students to be involved with computers but only in terms of surfing the Internet. In the cases where the activities were in the form of textbook drill and practice activities, the likelihood of passing the national exams (NE) in order to enter a CS School was the main motivator. Some teachers encouraged students to participate by using friendly tone (EF), humour (H), and by addressing questions (Q) to individual students and to the whole class. Certain teachers tried to involve their students in the leaning activities by threatening them with low grades (LG).

*Student involvement:* All students were interested in being involved in classroom settings with project-based activities interesting to them. When project work was related to uninteresting activities, all students remained involved but were bored. All students were interested in web browsing but without any learning aims. It is important to note that emphasizing good grades and the certainty of entering a CS School seemed to be insufficient motivating factors to involve students in the lesson. Teachers also used frequent questions to stimulate student interest but were unsuccessful in changing the boring or uncreative atmosphere. Moreover, invoking the equation 'uninvolvement in classroom activities equals low grades in the subject' appeared to make little sense to the students. In general, the context of textbook activities did not interest students to become involved in learning. Finally, it is important to note that no teacher tried to investigate students' previous knowledge or to help them make connections between this knowledge and the new learning concepts in focus. In addition, no teacher enabled students to summarize their knowledge at the end of each lesson.

The findings allow for seven basic profiles of CS teachers' teaching approaches:
*P1: Direct teaching, emphasizing preparation of students for national exams.* CS teachers (T1, T5, T9, T10, T11, T18, T19, and T23) that fall into this teacher profile usually emphasized the presentation of specific problems, aiming at the appropriate preparation of students to enter a computer science and engineering department and used the traditional blackboard and chalk environment. These teachers would usually begin their teaching sessions by presenting the students with simple textbook drill and practice activities, gradually progressing to more complicated ones. The style of communication these teachers used mainly emphasized monologue and direct instruction on how to write the solution of a problem on the blackboard. Most of these teachers asked questions but rarely received answers, students preferring to remain passive receptors. Some of these teachers (e.g. T1) used a pseudo-friendly but authoritarian, intimidating and sarcastic style (stargazing students' abilities and mistakes). Other teachers (e.g. T5) neither asked nor involved students in the lesson and provided no explanations, seemingly preferring a brief presentation of the lesson to cover the basic obligations of the job. It is worth noting that, despite basic motivation for participation in the lesson, such as the national exam-oriented learning activities, the threat of low grades and the asking of questions, student participation was limited.
*P2: Direct teaching in combination with the encouragement of student involvement in their learning.* Some teachers (T2,T4), in the context of the previously mentioned exam-oriented activities, used more student-oriented communication, including analytical presentation of the learning concepts in

focus, provision of further explanations, humour, questions to the whole class to correct the mistakes of their classmates and encouragement to solve the problems posed. It is worth mentioning that this kind of communication encouraged the students to become involved in their learning.

*P3: Teaching through reading and commending text-based materials.* Some CS teachers (T6, T8, T13, T14, and T16) performed their lessons by reading and commending text-based paper and PowerPoint materials. Most of these teachers did not provide their students with opportunities to express their opinions and to participate except through listening. In addition, some of these teachers cut the time dedicated for the specific lesson and apparently performed it merely to meet the basic obligations of the job. Student interest and active participation in such teaching settings was limited.

*P4: Whole class, non-structured discussion.* The teacher in this category (T15) did not use any learning material but tried to discuss some topics with her students by stating some opinions and asking appropriate questions. Students expressed some interest to this communication and some involvement in the discussion was observed. In terms of learning, there was no evidence, the whole session being unstructured and without specific learning aims, learning activities and evaluation procedures.

*P5: Leaving students free to surf the Internet.* These teachers (T17, T22) left their students free to surf the Internet. The interest of all students was engaged but no specific learning was observed, simply browsing by trial and error.

*P6: Organizing project-based settings.* Teachers with this profile (T3, T7, T12, T20, T21, T24, and T25) emphasized artistic project work, activities from the students' world, cooperation, a friendly style, encouragement and anonymously addressing a student's mistake to the whole class. It is important to note that, despite the fact that all students participated in these kinds of activities, they seemed to be happier working on projects corresponding to their own interests.

*P7: Encouraging problem-solving and critical thinking.* The teacher with this profile (T7) encouraged problem-solving, critical thinking and cooperation, and encouraged her students to participate. She also asked her students to reflect on their opinions and corrective action. In addition, she used humour, critical questions and a friendly style to motivate her students. As a result, all students seemed to be interested in this kind of work and actively participated in the proposed activities.

## Conclusions

Computer Science teachers' practices in real classrooms were investigated in the context of this study. In particular, real teaching sessions performed by 25 CS teachers were observed with a special focus on: a) how students' previous knowledge was investigated and how this knowledge was connected with the new learning concepts in focus, b) the kind of activities proposed, c) the kind of communication taking place, d) the handling of student mistakes, e) the number of students involved, f) the kind of motivation used to involve students in each specific lesson, g) the learning media used and h) summary and abstraction of the main learning aspects of each lesson. Data analysis helped us to create seven different CS teacher profiles, namely: P1: Direct teaching emphasizing preparation of students for national exams. P2: Direct teaching in combination with the encouragement of student involvement in learning. P3: Teaching

through reading and commending text-based materials. P4: Whole class, non-structured discussion. P5: Leaving students free to surf the Internet. P6: Organizing project-based settings, and P7: Encouraging problem-solving and critical thinking. These CS teachers' profiles can be taken into account in the design of appropriate specific programs for education of CS teachers so that to help them to adopt modern theories of learning in their teaching practices.

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