Conceptual Change in Algorithms Teaching: A Collaborative Approach

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SUMMARY

Teaching Algorithms is one of the most important and challenging educational topics regarding IT in High Schools. The aim of this research is to investigate whether and how Computer Supported Collaborative Learning (CSCL) environments facilitates the teacher to create activities and to define the mental models and conceptual changes during teaching in order to understand how students construct knowledge in the specific field during their activities. Two relevant activities for collaborative learning were developed with or without a computer; and from the study and the analysis of the activities interesting conclusions and questions.

KEYWORDS: *Algorithms, Conceptual change, CSCL, Role playing, Collaboration Analysis*

INTRODUCTION

Today, students acquire experience of using computers from their early childhood (computer games, mobile phones, computers). Thus they build representations (Baron, 2004) for abstract concepts as *process, memory, instruction, variable* etc., which are fundamental concepts of Algorithms. In this way they create cognitive models for the algorithms elements from early childhood. This could be a good example of how societal και cultural framework affects cognitive process, a fact that has been ignored for so long (Vosniadou, 1998)

The Algorithm is an important and fundamental concept for teaching Computer Science in Secondary Education. (Tuckler et. al. 1995). At the same time it is a concept has been proved to be difficult during its introduction in High School curricula. Despite the personal experiences of the students, we observe a significant difficulty in comprehending the concepts, keeping in mind than only 10% of the students the last class of Lyceum, who are competing in Greek National Examinations in Application Development, is solving the problems of the exams that demand

understanding of Algorithmic Logic. (Athanasopoulos et al. 2004)

Our research group has background work in research and development of CSCL systems: ModellingSpace, (Avouris et al, 2003, 2003a), Synergo (Voyiatzaki et al., 2004). A part of the research focuses in the creation of an environment that is adapted to the requirements of the teacher, who can create, coordinate and analyze collaborative learning activities, in a daily basis.

SHORT DESCRIPTION OF THE WORK

Our aim was to investigate whether and how a CSCL environment may support the teacher during tutoring:

a) to determine the existing conceptual models of his students related to algorithms,
b) to create new didactic activities in order to lead them to conceptual changes and to progress in terms of understanding an learning and
c) to observe and diagnose the ways students construct cognition while they participate in these activities.

The activities where about the collaborative solution of an algorithmic problem, by two-person groups. 30 students participated. Special emphasis was given in role playing between the students. In the particular school there has been previously a preliminary field study (Voyiatzaki et al., 2004).

The teacher created activities based on a simple Flow Chart. The students in the two-person groups shared two roles a) *Algorithm* and b) *Memory and Screen*. The student-Algorithm was tracing the flowchart and student-Memory-Screen was changing memory and screen contents following the instructions 'executed' by the Algorithm. The activity took place in two phases a) Shared collaboration on: *Activity Sheet (A.S) with Paper & Pencil* and communication: *face-to-face* b) Shared collaboration: *Synergo, a CSCL environment,* and communication*: exchange of written messages(chat*).

From previous experience, teaching Algorithms to the same students, the initial assumptions were the following:

(i) Students have created situated knowledge and mental models concerning concepts as variable, memory, and instruction.
(ii) Students can 'execute' branch instructions (*if then else*), but they cannot create loop instructions as easily (Athanasopoulos et al 2004)
(iii) The students face difficulties to 'execute' step-by-step an algorithms (while changing variables' values)
(iv) the top-level presentation of the flow chart leads to students' confusion, who by viewing the whole algorithm, do not comprehend that 'the computer executes only one command at a time and it is not aware of the next one'

During Phase A we have found some evidence for (i) and (ii), while for (iii) and (iv) there were only implications, because in the A.S it was not impossible all the actions of the students to be recorded, and to be connected with the recorded dialogues. For example, from A.S.

A) There were groups that have given to variables 'x' and 'maximum' different values (assumptions 1,iii, iv) while the instructions were:

Read x (meaning : give a value to variable x) Maximum ←x (meaning : Give to variable maximum the value of variable x)

B) there were groups that created control conditions as x>x (assumption ii).

During phase B Synergo was used , this a tool that permits synchronous collaboration of small groups of students who share an activity board and communicate through chat messages. Synergo also permits playback of the activity and analysis of activity logfiles, so it can be used for research in collaborative problem solving.

The method '*Transparent Flowchart'* was used to show the instruction that was 'executed' for in order to: a) support tracing step by step, and b) the content of the instructions to be initially invisible.

In addition two errors were on purpose introduced in the algorithm that was explored by the students: (a) the designed loop was not terminated (introduction of the new concept: *Algorithm termination*) and (b) there was no link with the terminating instruction (*END*) of the Algorithm.

Collaboration Analysis of the activity has produced the following findings:

a) The students had 'executed' the loop, but they could not insert a condition to terminate the loop (assumption ii),

b) the groups that 'executed' the loop more than three times, created a new method to mark with different colours the new execution of an already executed instruction of the loop, and had found that the loop is not terminating (assumption iv, and conceptual change that was not detected during phase a),

c) the students who found out that the Algorithm is not terminating had added a link to the 'END' instruction.

CONCLUSIONS - QUESTIONS

Mental models change and the socio-cultural environment influences the cognitive activity (Vosniadou,1998), especially in informatics teaching. Intending to use CSCL environments, like Synergo, in everyday class, we have found out that the teacher may be supported effectively, while designing, supporting, monitoring and analyzing collaborative learning activities. New questions for our research arise:

Using CSCL environments, which are the necessary tools to be developed in order to support teacher to identify conceptual changes during the activity? Can certain types of interactions and negotiation related to focused concepts, be milestones for the teacher to alert her to focus and support specific collaboration group, inside the class. These issues need further investigation and discussion.

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