# Learning Design: the views of Prospective Computer Professionals

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**This paper documents a learning design problem faced by computer science students and outlines some solutions. Twenty-eight Computer Science students at the Hellenic Open University participated in an experiment aimed at designing courses for Computer Science concepts. The systematic study presented in this paper argues and specifies that these students have difficulties with modern theories of learning in terms of the design of learner-centered courses. These difficulties mainly involve the design of appropriate lesson plans to include learning activities and questions that can support the development of basic cognitive skills in learners. Among the proposed solutions is to develop a special computer-based Constructivist Learning Task editor (CLT- Wizard) to help students design constructivist tasks for blended courses. The idea, the rationale, the architecture and the interface associated with these tools is presented through specific examples of possible implementation within LAMS, a web-based open source environment that supports Learning Design.**

### Keywords
Computer Science, Learning Design, Open and Distance Tertiary Education, Student views

## 1. Introduction

In this paper, we shall use the term ‘learning design’ to indicate all the results of a design for learning activities e.g. a learning task, a set of questions, the group formation, the learning materials to be used by the students, etc. [1]. Learning design is crucial in all types of education, namely; face-to-face, distance (including internet-based) and blended education.

Especially in e-learning, the concept of learning design is a relatively new area. Britain [2] identifies three general ideas that are central to this concept: a) people learn better when actively involved in doing something, b) learning activities may be sequenced or otherwise structured carefully and deliberately in a learning workflow to promote more effective learning and c) it would be useful to be able to record ‘learning designs’ for sharing and re-use in the future.

However, it is worth noting that, in a traditional face-to-face context, many teachers engage in the process of learning design as part of everyday lesson planning. Lesson planning is the process of determining the sequence of activities to be followed by a teacher or students when teaching/studying a topic. Engaging teachers through learning design would lead them to reflect on their pedagogical strategies. To this end, the awareness of the impact of different learning theories on learning design is crucial.

Traditional behaviorist learning theories [3] emphasize the teacher-telling approach to teaching that also assigns the passive role of listening to learners. According to these theories, lesson plans are usually structured in such a way as to begin by introducing learners to the theory related to the subject matter, subsequently progressing to the learning activities assigned for the consolidation of the aforementioned theory. These activities usually take the form of 'drill and practice'; that is, they focus more on the recipes needed to deal with certain trivial problems than on the basic concepts constituting the learning subject and on tasks emphasizing problem solving. As a result, the learning subject is mainly viewed as a sum of formulae; to some extent, this limits its conceptual nature. Moreover, the role of the media is downgraded to the impressive presentation of information for each specific learning subject and not to the provision of investigative contexts to encourage learners to construct their knowledge actively. In addition, individual work is favoured, while learning assessment mainly emphasizes learning outcomes and not the learning process. These traditional learning activities are usually boring and meaningless for learners, being mostly outside their sphere of interest. Thus, learners have to memorize the formulae and the entire learning content; as a result, the whole learning process is reduced to a meaningless activity.

Contrariwise, modern constructivist and social learning perspectives emphasize learning as an active, constructive and subjective activity where students are at the centre of the learning process and the role of teachers is to prepare fruitful environments to encourage their students to develop their critical thinking and their cognitive skills [4], [5]. To this end, the role of the learning task is crucial in motivating learners to be actively and passionately engaged in their learning [6], [7], [8]. According to these theories, holistic, real life learning tasks are appropriate as basic structural elements of the content presentation. Open learning tasks are also essential in providing learners with opportunities to develop their own solutions so that they develop strong motivation to learn [9]. Problem-solving tasks that put learners in an investigative mode can encourage them to construct their knowledge actively and acquire some essential problem-solving skills [6], [10]. Multiple-solution tasks are also significant in the encouragement of the expression of students' inter- and intra-individual differences [11]. Constructivist design of learning tasks emphasizes the fundamental concepts of the learning subject in question and not its details [4], [5], [6]. The role of the learning media in supporting learners to experiment, to express their intuitive knowledge and to form associated hypotheses is also acknowledged [12]. Group work is also viewed as crucial in encouraging learning through participants' sharing of knowledge and consequently the development of the Zone of Proximal Development of each individual [5]. Within such contexts, multiple means of communication are also encouraged, including group and whole class discussions. It is worth noting that, when such activities can be combined with appropriately posed questions, they will become powerful learning tools [13]. In fact, questioning plays a crucial role in the development of 'design thinking', implied in any scientific discipline but Computer Science and Engineering in particular [14].

The abundance of theoretical considerations and models that provide teachers with resources for the design of learning events remains largely unused in their real life practices [15]. In fact, teachers require more specific support in their learning design practices, such as specific tools and good examples of lesson plans. Thus, teacher encouragement and support for the learning design is clearly needed.

Especially when it comes to Computer Science (CS) Education, educators have adopted a rather deficient approach to learning design, possibly. because CS Education is a recently-developed scientific discipline. Yet, learning design should be an essential part of CS teachers' education. A number of studies have investigated CS teachers' opinions on CS curricula and on teaching and learning in CS as well as their real classroom practices [16],

[17], [18]; however, studies investigating Prospective CS Professionals' (PCSPs) attempts at learning design have not yet been reported. In this study, we investigate PCSPs' approaches to learning-design with the aim of exploiting the results to design specific computer tools that can support CS teachers in their attempts at learning-design. The essential role of suitably-designed tools to support teachers in their mindful and appropriate learning design has also been acknowledged by many researchers [19], [8].

It is worth noting that various tools to support web-based education already exist. These tools can be classified into four main categories: a) communication, such as chats, forums, bulletin boards, etc. b) content presentation, c) learning organization, such as group formation, timetabling, etc. and d) learning assessment, such as automatically-corrected multiple-choice questions, portfolios, etc. In addition, a number of tools that facilitate the design of sketchy plans for learning activities and roles that learners can play are also provided [1]. Recently, a tool that supports the design of questions to support students' basic cognitive skills has also been reported [20]. However, despite all of the above, tools that support teachers in constructivist task - design have not yet been reported.

In the following section of this paper, the context of the previously-mentioned study is presented followed by an analysis of the data. Next, the architecture of the proposed tools and especially of a Constructivist Learning Task Wizard (CLT-Wizard) is described and an example of its possible implementation within the context of an e-learning environment that supports Learning Design - namely the LAMS environment - is demonstrated. Finally, the advantages of the provision of the proposed CLT-Wizard are discussed and conclusions are drawn.

## 2. The Context of the Study

This study is part of a wider one that focuses on the investigation of PCSPs' learning-design approaches and, subsequently, on the design of appropriately supportive web-based tools in order for them to overcome their difficulties in taking into consideration modern social and constructivist theories of learning in their learning design practices. Twenty eight PCSPs at the Hellenic Open University participated in a learning design experiment. In this experiment they were asked to take into account modern constructivist and social views of learning to accomplish the following task: '*design lesson plans and activities for secondary level education students' learning of iteration algorithmic structures'*. The learning experiment took place during the Informatics and Education course provided by the School of Science and Technology of Hellenic Open University, an elective course offered to its CS undergraduate students. In terms of methodology, this is a qualitative study [21]. PCSPs worked in pairs. The data collected consisted of the PCSP's written reports to the task given. In the first stage of analysis of the data, each individual PCSP's responses to this task were identified and reported. In the second stage, data was coded using themes that emerged from them. Patterns from the data were extracted and the relationships among the coded segments were compared and contrasted. Using the research question as a guide, the data were categorised according to their common themes and relationships [22].

## 3. Data analysis

In this paper, a specific part of the results of the experiment mentioned above is presented. This part concerns the main characteristics of the lesson plans and activities designed by the PCSPs, with the emphasis on the kind of: a) tasks posed and b) questions designed by them. The analysis of these questions was carried out with special reference to the twenty-four basic cognitive skills [23].

In terms of the main learning activities designed by the PCSPs, eleven categories were created, these being presented in Table 1 and briefly discussed in the following section:

**Table 1** Questions and activities posed by PCSPs

| **Type of Activities posed** | | | **Questions posed and cognitive skills** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A) *Data collection cognitive skills* | | | C) *Data analysis cognitive skills* | | | D) *Data transcendence cognitive skills* | | |
| | f | f% | | f | f% | | f | f% | | f | f% |
| **I** | 304 | **35%** | D1 | 26 | **8%** | D8 | 30 | **9%** | D13 | 6 | 2% |
| **Q** | 323 | **37%** | D2 | 28 | **9%** | D9 | 2 | 1% | D14 | 10 | 3% |
| **P** | 40 | 5% | D3 | 87 | **27%** | D10 | 6 | 2% | D15 | 6 | 2% |
| **R** | 36 | 4% | Total | 141 | 44% | D11 | 0 | 0% | D16 | 2 | 1% |
| **M** | 86 | **10%** | B) *Data organization cognitive skills* | | | D12 | 16 | 5% | D17 | 2 | 1% |
| **E** | 14 | 2% | D4 | 14 | 4% | Total | 54 | 17% | D18 | 8 | 2% |
| **T** | 16 | 2% | D5 | 2 | 1% | | | | D19 | 12 | 4% |
| **A** | 22 | 3% | D6 | 26 | **8%** | | | | D20 | 6 | 2% |
| **G** | 28 | 3% | D7 | 0 | 0% | | | | D21 | 4 | 1% |
| **Ro** | 2 | 0% | Total | 42 | 13% | | | | D22 | 4 | 1% |
| **F** | 2 | 0% | | | | | | | D23 | 2 | 1% |
| **C** | 2 | 0% | | | | | | | D24 | 24 | **7%** |
| Total | **875** | | | | | | | | Total | 86 | 27% |

a) *Providing verbal information - task description* (I). This type of activity includes all teacher interventions providing any appropriate information regarding the task description. Despite the fact that the types of task posed by the PCSPs were mainly everyday problems taken from real life, especially from the learners' own world, these problems were usually posed in the form of 'drill and practice' tasks. It is worth noting that the solution to these tasks was usually designed to be proposed by the teacher after the students had failed at their first attempt.b) *Asking questions* (Q). This activity included all types of question asked by the teacher during each lesson. c) *Displaying solutions to similar tasks* (P). This is the presentation of examples of tasks similar to those posed, an aid for learners to acquire a better understanding of the concepts in focus. d) *Running a program* (R). This activity means that the learner runs an educational computer program provided ready by the teacher, e.g. using a specific program, learners tried different values for certain variables and viewed the results. e) *Providing learning materials for interaction* (M). This includes all types of learning material provided by the teacher, eg. educational software, lesson sheets. f) *Demonstrating solutions to simple examples* (E). This is mentioned in the presentation of the solution to basic and simple tasks, to be used as background for the tasks the learners have to face subsequently. g) *Presenting necessary theoretical information* (T). This means all verbal presentation of theory by the teacher. h) *Encouraging active participation and construction of a solution* (A). This includes all the teachers' verbal and written suggestions for the active construction of solutions to the given problems. i) *Encouraging group work* (G). Here, PCSPs' encouragement of collaboration and group activities is implied. j) *Assigning roles in groups* (Ro). This includes all suggestions by the teacher in assigning roles to the individual members of each group. k) *Participating in forums* (F). Here, the organization of a forum for group and whole class discussion is implied. I) *Constructing a problem* (C). This includes all suggestions made to PCSPs not only to construct but also to solve a problem related to the concepts in focus.

In terms of the frequency (f) of activities posed by PCSPs, the data analysis (see the first three columns of Table 1) revealed that a considerable percentage of activities (35%) emphasized the traditional teacher-speaking approach and the listening-passive role of the student.

However, there were some activities aimed at stimulating students' mental abilities by trying to get them to answer questions (37%). The analysis of these questions was performed with special reference to the four basic groups of cognitive skills [10], namely:

A) *Data collection skills,* including the specific cognitive skills of: Observation (D1), Recognition (D2) and Recall (D3). These skills are related to the learners' ability to correctly use their perception regarding specific data (D1), to recognize their basic properties (D2) and to recall any relative information (D3).

B) *Data organization skills,* including the skills of: Comparison (D4), Classification (D5), Ordering (D6) and Hierarchy (D7). These skills are associated with the learners' ability to detect similarities and differences among different data (D4), to find appropriate criteria to classify them (D5) and to put them in order (D6) as well as to form specific hierarchies using appropriate measurement units (D6).

C) *Data analysis skills,* including: Analysis (D8), Recognition of Relationships (D9), Pattern recognition (D10), Separation of facts from opinions (D11) and Clarification (D12). These skills include the learners' capability to analyse the given data in their basic parts (D8), to recognize relationships (D9), to discover patterns (D10), to be able to differentiate between their own personal opinions, which are arbitrary and sometimes biased, and facts that can be confirmed using specific data (D11) and also to be able to clarify the concepts related to these data through the use of specific examples (D12).

D) *Data transcendence skills,* including: Explanation (D13), Prediction (D14), Forming Hypotheses (D15), Conclusion (D16), Validation (D17), Error detection (D18), Implementation-Improvement (D19), Knowledge organization (D20), Summary (D21), Empathy (D22), Assessment /Evaluation (D23) and Reflection (D24). These specific skills are associated with the learners' ability: to integrate a specific phenomenon into a wide context, to interpret data in terms of cause-result relationships (D13) and to make predictions based on these relationships (D14), to form hypotheses about patterns/structures and principles (D15), to make valid conclusions documented by the data collected (D16), to validate the results (D17), to detect any inconsistencies and errors in the experimental procedure (D18), to make appropriate improvements (D19), to form some diagrammatic visual hierarchical organization of the knowledge constructed during the data analysis and data transcendence stages (D20), to summarize (D21), to make sense of other people's feelings and emotions regarding the situation at hand (D22), to define the effectiveness, appropriateness and value of the conclusions formed (D23) and, finally, to reflect on the whole learning process in order to assess, analyze and make connections that convert their experience into learning and lead to new understandings and appreciations [24].

As shown in Table 1, PCSPs mainly posed questions that emphasized the development of data collection cognitive skills (44%), and especially the recall of information (27%). It is worth noting that the development of higher cognitive skills -included in groups B, C, D- was inappropriately planned for in the lesson plans designed by PCSPs. Finally, it is noticeable that the lesson plans designed were not particularly fruitful in terms of variety of activities used.

## 3. Proposing appropriate tools for Learning Design

The systematic study presented in this paper showed that PCSPs have difficulties with modern theories of learning for the design of learner-centered courses. These difficulties mainly concern the design of appropriate lesson plans including learning activities and questions that can support the development of students' basic cognitive skills. To overcome these difficulties, we propose the development of: a) a Cognitive Skill Question-Wizard, b) a special Constructivist Learning Task- Wizard (CLT-Wizard), and c) a data base of Lesson Plan Templates, (LPT). These tools would be designed taking into account theoretical considerations of modern social and constructivist theories of learning, so that these tools could scaffold teachers to create learning activities and questions that would develop their students' critical thinking. In this paper, the focus is on the presentation of the design of a CLT-Wizard as the design of (a) has been reported in another work [20] and the design of (c) is in our future plans.

Among the various tools provided by e-learning environments are those that support the generation of learning tasks. Despite this fact, these tools are very generic and are not enriched in such a way as to provide specific support for the design of various types of tasks taking into account social and constructivist theories of learning. To this end, our proposed CLT-Wizard aims to act as a scaffolding tool for the design of learning tasks that support the development of critical thinking and basic cognitive skills in learners. Consequently, we exploit the theoretical analysis presented in the 'Introduction' section of this paper to describe in the following section the architecture of the proposed CLT-Wizard in terms of basic Aspects of Constructivist Task Design.

### *3.1. The architecture of the proposed CLT-Wizard*

ACTD1: *Holistic* tasks providing learners with opportunities to integrate the different kinds of knowledge they possess.

ACTD2: *Real-Life* tasks allowing easy learner engagement and also motivating their learning.

ACTD3: *Investigative* tasks providing students with opportunities to develop their cognitive skills.

ACTD4: *Multiple solution*-based tasks presenting learners with opportunities to express their inter- and intra- individual learning differences.

ACTD5: *Open* tasks allowing learners to come up with their own solutions so that they can express their inter-individual learning differences.

ACTD6: *Intuition*-based tasks supplying the expression of students' intuitive knowledge

ACTD7: *Problem-solving* tasks encouraging the development of learners' problem solving skills

ACTD8: *Project*-based tasks offering learners the chance to cooperate to meet deadlines and to face real life, holistic problems.

ACTD9: *Multiple Representation System*-based tasks giving learners the chance to express and integrate different kinds of knowledge they possess in order to acquire a broad view of the learning concept in focus.

ACTD10: *Tasks performed in the context of tools*, especially constructivist educational software and the Internet, providing learners with chances to interact with the knowledge of others integrated within these tools and environments.

With this in mind, different types of tool dedicated for the design of ten types of Constructivist Learning Tasks are proposed (CLTi, i=1…10). Each type of task is assigned to each different constructivist aspect mentioned in the previous section of the paper. For example, task CLT5 is dedicated to the development of the constructivist aspect ACDT5, and so on. For each type of task, a number of carefully designed examples (task-models) are also proposed for use by the teacher. These task-models (TMi, i=1…10) could be attached to the CLT-Wizard for the design of each type of specific task and are presented in Table 2.

**Table 2** List of basic type of constructivist tasks and associated examples

| **List of basic type of constructivist tasks** | **Examples of task-models (TMi, i=1,…10)** |
|---|---|
| ACTD1: Holistic | TM1: Compare the total cost of covering this irregular area using paving tiles of [x] dimensions and qualities. |
| ACTD2: Real-Life | TM2: Form a proposal and design the specific ground plan for a place dedicated for leisure activities and submit it to the mayor of your city [25]. |
| ACTD3: Investigative | TM3: Search for the concept of communication using your knowledge of Computer Science and Engineering |
| ACTD4: Multiple Solution-based | TM4: Construct pairs of similar triangles 'in as many ways as possible' [26]. |
| ACTD5: Open | TM5: Use data [x], all the symbols of a flowchart and all basic algorithmic structures 'in any possible way' and test the results. |
| ACTD6: Intuition-based | TM6: Fold these shapes in two to find out if they have axis of symmetries [27]. |
| ACTD7: Problem-Solving | TM7: Design a data base for patients and their specific health data (number and type of operations, days in hospital, number of fatalities, etc) |
| ACTD8: Projects | TM8: In your city, create an environmental station to measure the temperature of the environment three times per day. In addition, construct a program to display the average temperature per day of this city for one year. |
| ACTD9: Multiple Representation System-based | TM9: Transform this non-convex polygon into an equivalent one using these four representation systems [28] |
| ACTD10: Performed in the context of constructivist tools and the Internet | TM10: Exploit the features of Cabri-Geometry II to construct equivalent triangles 'in as many ways as possible' [11] |

## 4. An example of implementation of the proposed tools within LAMS

LAMS (Learning Activity Management System; [29]) is an open source tool for designing, managing and delivering learning activities. LAMS is written in Java and runs on the most common Web browsers, although Flash is also required. By using LAMS, teachers gain access to a highly intuitive visual authoring environment for creating sequences of learning activities, eg. individual tasks, small group work and whole class activities. The creation of sequences of learning activities which involve groups of learners interacting within a structured set of collaborative environments, referred to as "learning design", is less common and LAMS allows teachers to both create and deliver such sequences. In fact, LAMS provides tools that support various activities such as communication, presentation of information, writing and sharing resources as well as posing and answering questions. On the whole, LAMS provides tools to encourage teachers to design their lesson plans, using various pedagogical approaches, and also to monitor their students' progress through a lesson plan. Throughout a LAMS sequence, perspective teachers are required to think about all aspects of their lessons in detail and the software enables them to experience the lesson themselves via a preview mode before classroom use. Yet, despite all of the above, the tools that support the generation of learning tasks are very generic. Consequently, we suggest the integration of the proposed CLT-Wizard within the Noticeboard tool provided by LAMS (see Figure 2).

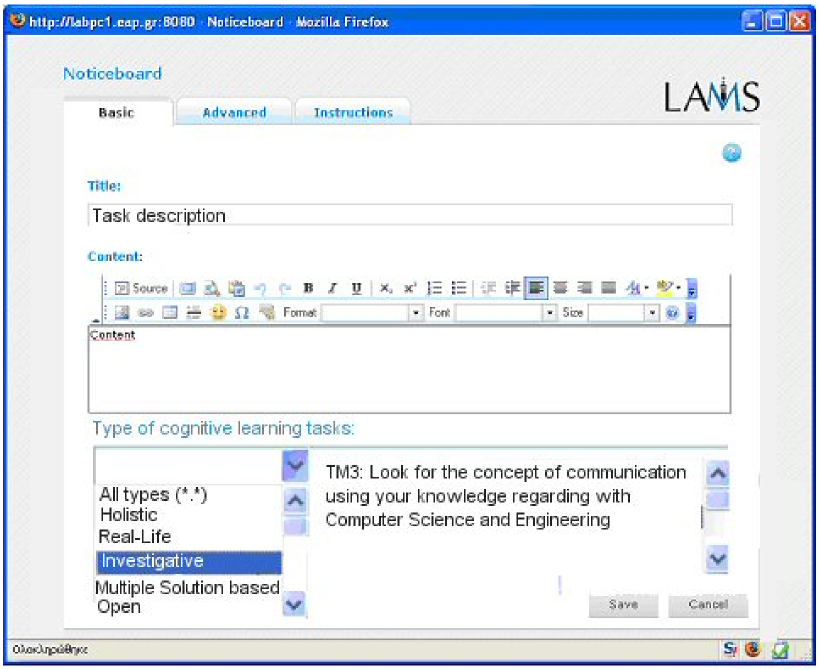


**Figure 2** Proposed integration of the Noticeboard tool provided by LAMS with the CLT-Wizard

## 5. Conclusions and plans for future work

This paper presented the views of prospective Computer Science professionals regarding learning design as expressed through their involvement in planning lessons to teach secondary level education students basic concepts of Computer Science. The analysis of the data showed that PCSPs are deficient in creating appropriate: a) constructivist tasks, b) questions that encourage the development of learners' cognitive skills and c) fruitful lesson plans that integrate various learning activities. To this end, the idea of a Constructivist Learning Task editor – namely, the Constructivist Learning Task Wizard or CLT- Wizard - dedicated to help teachers in their attempts to design appropriate tasks within the framework of modern constructivist and social theories of learning has been proposed. In fact, the CLT-Wizard consists of ten tools to support the following type of constructivist tasks: Holistic, Real-Life, Investigative, Multiple Solution-based, Open, Intuition-based, Problem-Solving, Projects and Multiple Representation System-based tasks to be performed within the context of constructivist tools and the Internet.

For each type of task, task-models are also designed to present the teachers with useful ideas and to help them to design appropriate tasks. Proposals for the integration of this CLT-Wizard within the 'Noticeboard' tool provided by LAMS are also presented. However, it is worth noting that the architecture of the proposed CLT-Wizard can be integrated into any e-learning environments that support learning design. By using the CLT-Wizard, teachers have the opportunity to design tasks, not by chance but in a focused way, aiming towards the development of constructivist learning settings. In designing such tasks, teachers are also provided with task-models which can act as scaffolding elements in this process. The potential features of the proposed CLT-Wizard being theoretical, field studies are deemed appropriate to test its impact on the attempts of real teachers at learning design. Finally, the said CLT-Wizard can be enriched by different types of constructivist tasks and more task-models.

## References


1. Koper R and Tattersall, C. Learning Design: A Handbook on Modelling and Delivering Networked Education and Training. Berlin: Springer-Verlang, 2005.
2. Britain S. A Review of Learning Design: Concept, Specifications and Tools, Report for the JISC E-learning Pedagogy Programme, 2004. Retrieved 12 May 2006, from http://www.jisc.ac.uk/uploaded_documents/ACF83C.doc
3. Skinner B F. The Technology of Teaching. New York : Appleton, 1968.
4. von Glasersfeld. E. Learning as a constructive activity. In C. Janvier (Eds), Problems of representation in teaching and learning of mathematics. London: Lawrence Erlbaum associates, 1987; 3-18.
5. Vygotsky L. Mind in Society. Cambridge: Harvard University Press, 1978.
6. Nardi B A. Studying context: A comparison of activity theory, situated action models, and distributed cognition. In B.A. Nardi (Ed.), Context and consciousness: Activity theory and human-computer interaction, Cambridge, MA: MIT Press, 1996.
7. Noss R & Hoyles C. Windows on mathematical meanings: Learning Cultures and Computers. Dordrecht : Kluwer Academic Publishers,1996.
8. Jonassen, D. H. Revisiting Activity Theory as a Framework for Designing Student-Centered Learning Environments. In D.H. Jonassen & S.M. Land (Eds), Theoretical Foundations of Learning Environments, Lawrence Erlbaum Associates, London, 2000; pp. 89-121.
9. Kordaki M. Pupils' Choice of Computer Tools as affected by the Learning Context. Journal for Interactive Learning Research, 15(3), 2004; 235-255.
10. Fishman J B. How Activity Fosters CMC Tool Use in Classrooms: Reinventing Innovations in Local Contexts. Journal for Interactive Learning Research, 3(1), 2000; 3-28.
11. Kordaki M & Balomenou A. Challenging students to view the concept of area in triangles in a broader context: exploiting the tools of Cabri II. International Journal of Computers for Mathematical Learning, 11(1), 2006; pp. 99-135.
12. Laborde C. The computer as part of the learning environment: the case of geometry. In C. Keitel & K. Ruthven (Eds), Learning from computers: Mathematics Education and Technology . Berlin: Springer - Verlag. 1993; pp. 48-67.
13. Barnes J, Aristotle Posterior Analytics. (Translation, 2nd ed.). NY: Oxford University Press, 1994.
14. Dym C L, and Little L. Engineering design: A project-Based Introduction. NY: John Wiley (2nd Ed.), 2003.
15. Fosnot C. Constructivism: Theory, Perspectives and Practice. NY: Teachers College Press, 1966.
16. Christakoudis Ch and Kordaki M. Fundamentals of Computer Science for 7-9 grades: views of teachers. 4$^{th}$ Pan-Hellenic Conference 'ICT in Education' (with International Participation). Athens, Greece, September 2004, 2004; pp. 198-206.
17. Kordaki, M. and Kalyva, G. (2006). Teacher views on Computer Science Curricula in Secondary Education: Present and Future. In Proceedings (CD-ROM) of IFIP WG 3.1, 3.3, & 3.5 Joint Conference, "Imagining the Future for ICT in Education", 26-30 June, Alesund, Norway.
18. Kalyva G and Kordaki M. Computer Science Teachers' Real Practices: a case study. In Proceedings of International Conference on Information and Communication Technologies in Education (ICICTE), Rhodes, Greece, July 6-8, 2006; pp.245-251.
19. Babiuk G. A Full Bag of "Tech Tools" enhances the reflective process in Teacher Education. In C. Crawford et al. (Eds.), Proceedings of Society for Information Technology and Teacher Education International Conference. Chesapeake, VA: AACE, 2005; 1873-1877.
20. Kordaki M, Papadakis S, Hadzilacos T. Providing tools for the development of cognitive skills in the context of Learning Design-based e-learning environments. Proceedings of *World Conference on E-Learning in Corporate, Government, Healthcare & Higher* Education (E-Learn 2007), October, 15-19, Quebec Canada, USA, Chesapeake, VA: AACE2007
21. Cohen L & Manion L. Research Methods in Education. London: Routledge, 1989.
22. Babbie E.The Practice of Social Research. CA: Wadsworth Publishing Company,1989.
23. Matsaggouras E. Teaching Strategies. Athens: Gutenberg, 1997.

**24.** Boud D, Keogh R, Walker D. (). Promoting reflection in learning: a model. In D. Boud, R. Keogh & D. Walker (Eds), Reflection: Turning experience into learning, NY:Nichols, 1985; pp. 18-40.
**25.** Kordaki M, Potari D. 'Childrens' approaches on area measurement through Different Contexts'. Journal of Mathematical Behavior, 17(3), 1998; 303-316.
**26.** Mastrogiannis A, Kordaki M. The concept of similarity in triangles within the context of tools of Cabri-Geometry II. In A. Mendez-Vilas, A., Solano Martin, J. Gonzalez Mesa, and J.A. Gonzalez Mesa, (Eds), 4rth International Conference on Multimedia and Information and Communication Technologies in Education (m-ICTE2006). (pp. 641-645), Seville, Spain, 22-25, November, 2006.
**27.** Mastrogiannis A, Kordaki M. Bilateral Symmetry: primary level pupils' conceptions. 2nd Pan-Hellenic Conference, Union of the Researchers of Mathematics Education, Alexandroupoli, 23-25, November, 2007, (accepted).
**28.** Kordaki M. The effect of tools of a computer microworld on students' strategies regarding the concept of conservation of area. Educational Studies in Mathematics, 52, 2003; 177-209.
**29.** LAMS: http://www.lamsfoundation.org/