

CMINDS: TEACHING PROGRAMMING AS A MEANS FOR DEVELOPING EARLY ANALYTICAL, STRUCTURAL, AND CRITICAL MINDS

O. Heidmann, H. Tsalapatas

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A. A Short Overview of the Proposed Presentation Content

Analytical and critical thinking are transversal learning skills that help an individual excel in wide areas, professional, social, civic, and personal. They facilitate the establishment of objectives, the analysis of a problem into constituent components, evaluation of alternative solutions and implementation routes, and sound decision making. The applicability of analytical thinking is evident throughout an individual's life as a child and as an adult, academically and professionally; in school, it offers benefits in wide subjects, ranging from science and technology to humanities and art.

Despite the strong potential of analytical thinking as an approach for wider problem solving and addressing of life's challenges, educational practices in primary school are not representative of its importance. In fact, analytical thinking in primary education, where this exists, is limited to arithmetic problem solving. Teaching approaches in many cases revolve around the solution of, often, dry exercises. Current teaching practices fail to leverage the inherent link between creativity and analytical thinking, which emerges when children are encouraged to introduce innovative solutions in the context of brainstorming, collaborative learning sessions. In addition, primary education formal curricula and supporting learning material in many European countries do not adequately deploy technology as a complementary learning tool. As a result, common didactical approaches in elementary education do not take full advantage of the learning potential of technology enhanced learning activities, which may enhance the educational experience for learners and teachers, support emerging didactical frameworks such as exploration and virtual experimentation, and promote the development of structural, independent, and critical minds beyond traditional, lecture-based instruction.

The cMinds project, which is the theme of this presentation, aims at addressing this gap in primary education by introducing innovative inquiry-, project-, and game-based didactical frameworks that take advantage of visual programming concepts towards the development of analytical, entrepreneurial, and creative minds. The project exploits the structural nature of programming to help young learners develop algorithmic thinking and problem solving skills. The proposed didactical framework is validated in practice through the design and development of an on-line learning environment as well as virtual learning activities that help children identify the parameters of a problem, experiment with alternative solutions, visualize graphically the outcomes of their efforts connecting cause and effect, and select an optimal solution based on predefined indicators related to the objectives of a given problem as, for example, speed, cost, and more. Tying theory to practice, the cMinds learning environment promotes well-accepted algorithmic approaches towards problem solving, including brute force, divide and conquer, reduce and conquer, and more; however, computational complexity is hidden from learners who are exposed to age-appropriate, graphical, virtual learning puzzles.

Results are validated in real-life conditions in schools in Greece, Romania, the Czech Republic, and Sweden. The project runs from 2010 to 2012 and is partly funded by the European Commission (Life Long Learning Programme, Comenius Action).

B. Participants Benefits

The audience will have the opportunity to see a presentation of the theoretical didactical framework that underpins the cMinds virtual learning environment and activities on the development of analytical thinking skills through the teaching of programming. The design of the cMinds learning methodologies will be put in perspective through references to the current status quo in European primary education on analytical skill development and through a review of other past work on virtual programming environments for the targeted age group.

More importantly, the presentation will include an actual, real-time demonstration of the cMinds virtual learning environment. The demonstration will further include examples of several virtual learning activities developed through the learning environment that demonstrate is age appropriate ways programming constructs such as conditionals, loops, and more and continue with algorithmic exercises that promote analytical skill development.

Finally, the audience will receive information on early validation results from the deployment of the activities in real-life learning conditions in schools in Greece, the Czech Republic, Sweden, and Romania. Evaluation-related information will address issues on the relevance, acceptance, and effectiveness of the proposed educational methodologies and virtual learning tools.

C. Practical Outcomes

C.1 What did this initiative / project do?

cMinds uses programming concepts as a means for developing **analytical thinking** in elementary school children through **wider blended learning** that combines **inquiry and project-based individual exploration**. The project aims to develop analytical, critical, and structural skills through advanced explorative and collaborative didactical frameworks that take advantage of information and communication technology and specifically visual programming concepts.

The main outcome of the project is a virtual learning environment and proof-of-concept learning activities for analytical skill building through visual programming. Notably, the project does not aim to simply improve digital skills of children. However, it naturally contributes to digital literacy. Learning tools are developed taking into account the fact that today's children are "digitally literate" and have advanced expectations from software design based on their exposure to recreational and educational software services.

For maximizing impact, the proposed innovative learning frameworks are designed for integration into existing school curricula, introducing a positive teaching environment supported through emerging explorative learning approaches and educational technology. This distinguishes project outcomes from off-the-shelf software packages aimed for individual use by children at home.

Aiming at European-level applicability, the project validates outcomes in four countries with differing school systems, namely Greece, Sweden, the Czech Republic, and Romania.

C.2 Why was the initiative / project undertaken?

Over the past few years there is a shift in European educational objectives towards the development of basic, transversal learning competencies that are applicable in wide learning settings independently of subject area. Such skills include analytical thinking,

entrepreneurial learning, independent learning, working in groups, working with different cultures, learning-to-learn, and more. This tendency is evident in the Education and Training Objectives (ET2020) of the European Commission, which demonstrate a need for adapting and updating existing school systems with the objective of bridging the gap between education and work and raising individuals that can effectively act in a fluid environment.

In line with these emerging educational policies, cMinds aims to address a gap in European primary education in terms of building transversal learning skills, and specifically analytical and critical thinking. High level project objectives are achieved through the design, development, and validation in real-life conditions of innovative educational frameworks that leverage ICT, and specifically visual programming, towards building independent minds and helping learners think on their feet. The project aims to enhance learning experiences for both students and teachers through the development of technology-enhanced learning activities that extend existing instructional practices taking them a step further through age-appropriate virtual experimentation.

C.3 What are the results of the initiative / project

Specific outcomes of the cMinds project are:

1. An analysis of the current status quo in European primary education on: (i) analytical skill building (ii) deployment of innovative educational approaches including explorative, collaborative, and game-based learning (iii) teaching of programming (iv) use of ICT as an educational tool and (v) related teacher-training services
2. An inquiry-based methodological learning framework that deploys virtual programming towards analytical skill development
3. A virtual learning environment for validating in practice the proposed didactical framework for analytical skill building. The environment includes: (i) a tutorial area where programming concepts such as conditional and loops are demonstrated graphically (ii) a “robot” area through which children graphically program solutions to specific exercises (iii) a visualization area that shows the outcomes of solutions introduced by children
4. Virtual learning exercises built on the cMinds learning environment that act as proof-of-concept learning material designed for use in the classroom in the context of wider end-to-end learning activities
5. Evaluation of outcomes through real-life learning experiments in several European countries
6. Instructional process support material in the form of how-to videos, manuals, and learning sheets that help teachers step-by-step in introducing the proposed learning methodologies and tools in their practices

C.4 What impact did this initiative / project have?

The project addresses the needs and desires of direct and indirect stakeholders in primary education, and specifically learners, teachers, teacher-trainers, curricula designers, parents, and the general public. A particular focus is given to the learning requirements of direct stakeholders, namely learners and teachers. Specifically, teachers in the field often point to the lack of supporting instructional material in digital form. cMinds addresses this issue through the development of learning environments targeting the needs of primary education. As noted earlier, the project aims to develop tools for use in classrooms throughout Europe, as opposed to develop off-the-shelf educational aids. Deploying formal school channels contributes to maximizing the impact of project results.

Approval from Ministries of Education, such as the Greek Ministry of education, will be pursued on the appropriateness of the cMinds tools as educational complementary material once they have been sufficiently tested in early and stable versions in real-life classroom conditions in Greece, Sweden, the Czech Republic, and Romania.

On the other hand, the cMinds project develops a school network through which learners and teachers can exchange know-how, findings, and experiences from joint learning activities related to the cMinds tools.

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