USE OF NEW EDUCATIONAL TECHNOLOGY IN UNDERGRADUATE EDUCATION

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ABSTRACT

This paper presents some achievements of the project entitled "Teaching Programming Towards Early Development of Analytical, Structural, and Critical Minds" - cMinds, financed by European Commission. The recent developments and results obtained during elaboration of the user requirements report are presented, both at Romanian and European level.

Keywords: analitycal thinking, critical thinking, programming

1. Introduction

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 school are not representative of its importance. 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.

cMinds project aims to bridge the gap in education practices on analytical skill development. The project deploys technology, and more specifically visual programming concepts, as a means for building problem solving skills among young children [5].

2. cMinds project objectives

cMinds aims to use programming concepts as a means for developing analytical thinking in school students 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. For maximizing impact, the proposed innovative frameworks are designed for integration into existing school curricula, introducing a positive teaching environment supported through emerging explorative learning approaches and educational technology.

Rather than focusing on the teaching of programming, the project aims to deploy programming principles as an avenue for promoting analytical thinking and independent learning in a wider collaborative educational environment. The structured nature of programming, which is inherently analytical, offers an efficient paradigm for problem deconstruction and precise, step-wise solution building. It is based on universal logic that is inherent in all cultures and thus is inclusive.

Visual programming is used in cMinds in the context of inquiry and project based didactical methodologies that help pupils understand the problem to be solved, analyze it, and visualize potential solutions.

The proposed learning design is heavily based on graphical visualization implemented through age-appropriate on-line educational software applications. The advantages of the proposed graphical approach are many for the targeted group: visual demonstrations overcome language barriers; they conceal computational complexity that may not be appropriate for school pupils; most importantly, they allow pupils from different social environments and countries to use common tools and thus discuss findings in a collaborative manner under a common context through teacher mediation.

The cMinds methodological didactical framework is validated through the development of on-line virtual learning tools. Blended learning activities are supported through on-line available tools that include:

● Demonstration of basic programming concepts,
● Problem deconstruction and identification of components,
● Identification of objectives,
● Alternatives evaluation and visualization,
● Solution modeling,
● Process optimization through iteration,
● Solution synthesis and decision making.

The applications offer direct feedback that help pupils make the connection between cause and effect; visualization of solutions can inspire pupils's curiosity, promote creativity, and increase motivation.

3. The target sector

cMinds targets the undergraduate education sector in Europe aiming to meet needs in learning design and delivery towards the development of analytical thinking skills. Within this sector, a number of stakeholder groups can be identified that stand to gain directly or indirectly from project methodologies, tools, and good practices.

Direct stakeholders are the undergraduate learners and teachers who are the ultimate beneficiaries of cMinds objectives, and specifically the design and implementation of didactical frameworks, tools, and learning activities with a specific focus on their particular learning needs. On the other hand, a number of other groups such as policy makers, administrators, teacher-training organizations, the educational software applications industry, didactical process and curricula designers, parents and the general public benefit indirectly from the project outcomes.

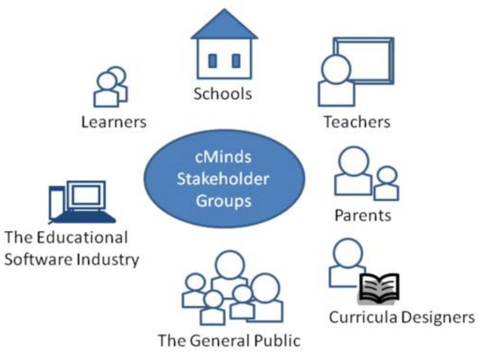

Fig. 1 - cMinds Stakeholder Map

It should be noted that the cMinds methodological didactical approach that deploys inquiry-based learning in the context of virtual exploration, while in the context of this project is being validated for meeting undergraduate education learning requirements, is relevant and applicable to wider learning practices. Consequently, in the long term additional groups may stand to benefit from the incorporation of cMinds methodologies into their individualized needs and desires, including the secondary, higher, professional, and vocational education sectors. The analysis of the needs of these groups and potential deployment, through adaptations where appropriate, of the cMinds outcomes are the subject of the cMinds exploitation strategy.

Figure 1 shows a graphical representation of cMinds stakeholder groups.

4. Explorative learning activities

In Romanian schools, explorative learning is used to select phases of class lessons and specifically when pupils are introduced to new concepts and when they deduct rules and patterns. At ”Transilvania” Economic College of Tîrgu Mureş (CETTM) explorative learning is used in a variety of subjects throughout the school programs, ranging from language learning to science education. This practice is common in Romanian colleges in general.

In order to introduce the reader to practical applications of explorative and collaborative learning in primary education, a discussion of related activities at CETTM follows:

● In English language learning is practiced through story-telling. In the context of a story pupils learn how to use spoken language, written language, and visual communication. The teacher uses multimedia educational material such as interactive books on DVDs to encourage pupils to use technology for knowledge exploration and discovery on the location and content of the story, data interpretation, and summarizing the information they read in books.

● In natural sciences pupils are involved in project-based exploration on animals and wildlife. Pupils should find information on animals, such as their dimensions, skills, way of life, and more. Pupils organise this information in a database and compare the results in the context of class collaboration and discussions to decide which animals are best suited to live in a colony in the Equatorial jungle. In natural sciences, learners have the opportunity to see videos on the topic of animals; learners discuss with their each other and with their teacher the appearance of animals and their ability to adapt to varying living environments. The presentations are delivered with the support of a DVD player and projector. The teacher then encourages learners to expand their observations, analysis, and presentations by comparing the characteristics and behavior of varying animal species as well as their habitats. Making a connection between explorative instructional delivery and technology, the teacher explains how ICT can contribute to enhance the educational process on the subject at hand, i.e. natural sciences. The teacher uses specific terminology to explain how to use video cameras to record observations and how to use computers for information recording, organizing, and analyzing.

Explorative learning is being used in European schools widely. The term is used as an umbrella to cover a variety of didactical approaches; this includes game-based learning, inquiry-based learning, project-based learning, story-telling, group collaboration, hands-on learning, experiential learning, and more. While each school does not use all of the above listed approaches, all schools documented learning practices that deploy exploration as this is described above.

Project-based and story-telling approaches are popular, followed by group collaboration, presentations, and discussion of findings. The appeal of this method may lie on its age-appropriateness, as it can be easily followed by learners who are excited to be engaged in activities that go beyond traditional lectures. Another contributing factor for the broad practice of this method may be its inclusiveness as it engages the entire class in collaboration and enables children to learn from each other.

Exploration is for the most part executed off-line. On-line services deployed are typically limited to the Internet, which is used as a tool for performing research.

ICT equipment used for the support of educational processes includes mostly PCs and projectors; failure to use more sophisticated equipment is due to lack of supporting infrastructure in the schools, lack of funding, as well as insufficient technical support and training for teachers on the use of technology in education.

5. Analytical thinking

Similarly to the school environments in other countries as this is described above, analytical thinking is used in a variety of subjects in Romanian schools. Following are examples of practicing analytical thinking in the context of school activities at CETTM. These examples provide insight on related practices throughout the Romanian undergraduate education system:

● Analytical thinking in mathematics education: the objective of a common exercise is to help learners grasp the concept of the value of 100 lei. The objective of the exercise is to spend as closely to 100 lei as possible.

Learners are provided with calculus tables with the help of which they select items that they then "purchase". Learners use formulas to calculate their total spending aiming at maximizing their spending without exceeding 100 lei. Analytical thinking is promoted through the understanding of objectives and the development of a solution that follows specific rules and constraints.

● Analytical thinking in literature reading: the learning activity involves reading a story and attempt to predict activities and outcomes based through inquiries. The story is presented in fragments aiming to foster predictive reading. After reading each passage pupils collaboratively discuss the text and fill in a "table of predictions". The teacher guides the discussion by asking questions that require children to reflect on what they read and anticipate what will happen next in the story. Analytical thinking is promoted through reflection of alternative outcomes.

The above examples demonstrate the deployment of analytical thinking in subjects that may significantly vary, in this particular case mathematics and literature.

Analytical skill development practices are already deployed in European schools. Analytical thinking is inherent in mathematical education, where logic and the development of mathematical computational skills are promoted. In addition, analytical thinking is often an integral part of science and technology education where project-based approaches that follow design, implementation, and evaluation of outcomes are introduced.

However, the analysis also demonstrated that analytical thinking is used in a variety of other subjects ranging from humanities to literature thus expanding the scope of thematic areas where the skill is considered applicable. In this context, the interpretation of the term "analytical thinking" departs from the more commonly understood use of the method in mathematics and technology to cover other methods of solution induction and analysis of alternatives including critical text reading, Socratic inquiry, role playing in simulations of real-life, and thinking out of the box.

In most cases, technology is not used for enhancing analytical skill development. When technology does enhance educational processes, it is in the form of commonly available tools such as PC and calculators. The analysis demonstrates a significant absence of software tools for analytical skill development from European classrooms. This may be a result of funding constraints, teacher support, and formal evaluation of related software packages in terms of their suitability for use in classrooms in primary education.

6. Teacher skill development on ICT

The availability of ICT is not, in itself, adequate to intensify learning and teaching practices. Many researchers have revealed that while ICT can be motivating and engage pupils in learning more efficiently sustained impact depends on the ability of the teacher to integrate ICT into the learning experience of pupils in a way that fully exploits the benefits of technology-enhanced learning [2].

Regarding the development of basic ICT skills among teachers, there are many ways to introduce related training; training may cover a broad range of skills and qualifications, including the use of basic software, understanding of the function of equipment including computers as well as emerging mobile devices, the effective use of the Internet as a learning tool, the effective, appropriate, and safe use of on-line social services to enhance collaboration and networking, and a lots more. Nevertheless, there is no in-depth, well documented research on how teachers could best embed successfully ICT into their classroom practices.

On the other hand, teacher training should not only encompass the development of ICT skills per se but also a complete mastery of ICT as a pedagogical tool. With this objective in mind, teacher training ideally should consist of two planning stages: (i) technical training and support and (ii) preparation to incorporate ICT in the curricula. The latter is the most crucial and highlights the need for the establishment of good practice recommendations on how ICT-based learning design can be embedded into traditional instruction.

7. Technical infrastructure requirements

A set of technical principles must be considered in setting specifications and identifying school infrastructure requirements aiming at supporting the proposed learning activities that deploy on-line tools in a sustainable and coherent manner.

Generally, a school's technical infrastructure provides a technological foundation intending to integrate best-of-class technology solutions in every area of the learning experience, taking into account available financial resources [4].

As can be observed from the above status quo analysis, most schools possess computer labs in various degrees of equipment completeness and sophistication.

The majority of schools have access to medium-quality and strength devices, network infrastructure, and application software that are directly used by students, teachers, and school staff. However, the ongoing costs of maintaining and upgrading laboratories based on the rapid evolution of technology and the ever increasing technological requirements of emerging software packages introduce substantial barriers to effective utilization and return on investment.

However, one of the main objectives of designing the school of the future is to actively engage children in personalized learning in an advanced technology enabled school environment that follows technical advancements enjoyed in everyday life [1]. ICT equipment in schools should support high performance computing and communications commonly available outside of school. Schools should strive to introduce classroom-friendly technologies such as desktop computers, laptops, interactive digital whiteboards, e-books, data projectors, digital cameras, printers, and scanners.

Regarding network infrastructure, pupils should have at their disposal multimedia-capable and Internet-connected computers in order to access a wide range of applications and services. Furthermore, the school network infrastructure components should ideally include:

- Internal and external communications services, cabling, and equipment,
- Standardization of high-maintenance infrastructure, such as telecommunication services, server computers, and associated storage devices, aiming to facilitate cost- and time-effective maintenance and technical support,
- Wireless connectivity throughout the building and extended campus, which will enable easier network access,
- Environmentally-friendly equipment management aiming to reduce the school's energy consumption related to computer use,
- Operating software for server computers,
- Access to open-source educational and other supporting software services and packages,
- Access to technical support services and personnel for effective laboratory and equipment maintenance.

Moreover, the school of the future should embrace advanced technologies that enable access to key educational application software packages and services. It is apparent that educational software enhances learner interaction while providing value-adding functionality for learning process support. Examples of services that could enhance learning processes in schools include [3]:

- Educational content management systems,
- Learning management systems,
- Finance and assets systems,
- Staff and student management systems,
- Assessment and reporting systems.

Teacher involvement in cMinds project plays a crucial role in improving their professional development; they are the second of the identified stakeholder groups who is directly targeted through the cMinds pilot applications and didactical methodologies. Particularly, they participate actively not only in the design of educational activities but also in coordinating validation activities through learner supervision, ensuring that the final product is applicable to the actual needs of children in real-life settings.

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