The Development of Students' Metacognitive Competences. A Case Study

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Abstract: In the information society metacognitive competencies are essential. Based on some activities from the Enrichment Instrumental Program elaborated by professor Reuven Feuerstein we have designed a program for developing the students capacities of selfcontrol, selfknowing and intelectual learning strategies. The case study presents the formation of students' metacognitive competences at the "Lucian Blaga" University of Sibiu, "Hermann Oberth" Faculty of Enginereeing, Department of Computers Sciences. A Web based application has been developed in order to enable students to self-evaluate their metacognitive competencies and to acquire self-regulatory abilities.
Keywords: metacognitive competences, instrumental enrichment program, computer science, higher education, relational competences, motivation for didactic career, web based application.

1 Introduction

Metacognitive skills are a must for students preparing to have a career in the information/-knowledge society. For those that want to embrace a didactic career that is essential. Therefore the Department for Teaching Staff Training [8] has started a special training program consisting of two modules. The education plans for the first module consists of the following courses: psychology of education, pedagogy 1 (foundations of pedagogy, curriculum theory and methodology), pedagogy 2 (instruction theory and methodology, evaluation theory and methodology), specialty didactics, teaching practice, optional courses, final evaluation-didactic portfolio [9]. In the second module the following courses are included: curriculum area didactics, class management, counseling and vocational guidance, computer-assisted instruction, psychology of education, optional I (1 of 4: intercultural education, educational politics, contemporary pedagogical doctrines, management of school organization), optional II (1 of 4: psycho-pedagogy of adults, foundations of special psycho-pedagogy, sociology of education, research methodology in the sciences of education), final evaluation-project, teaching probation (42 hours - for those who did not teach during the period between the attendance of the first module and the enrollment at the second module).

2 Developing Students' Metacognitive Competences

Metacognitive skills development is an important formative intellectual object in education of the students, as reaching this level involves a route through effective education, appropriate to each one in particular [6]. Metacognitive skills suppose that students are aware of their own cognitive activity, i.e. learning activity, and self-adjustment mechanisms consisting in cognitive controls (rules, procedures, strategies).

2.1   The Background

The development of metacognitive skills goes in the same direction with the strategies used in developing cognition. The main steps in the formation, in the affirmation of conscience gripping meta-cognition are:

• affirmation of trust and intuition (AH Schoenfeld's model) in solving the problems, or tasks, based on knowledge, on previous experiences; in this step the trainer looks to identify in the student a sense of referral tasks, intuition, a way of understanding and finding solutions taking into account all possibilities;

• personal reflection on the knowledge involved; the student must become aware of the solutions found, the instruments used, her/his capacity of analysis and comparison, the way to analyse the difficulties of other methods previously used;

• self-awareness or awareness of effective solutions addresses the solving style, based on self-observation, analysis of results and of the ways to solve, progress and cognitive acting.

The development stages show that metacognitive skills are associated with knowledge from management, and construction and that these are the conditions in which the knowledge appears. Cognition managerial approach reveals the fact that metacognitive includes: awareness of how to understand the problem and how to solve it, planning the processes and finding the pathways necessary, monitoring the application solutions, the resources used, constraints, necessary instruments, decisions and analysis of results [4].

F.P. Büchel considers that training of metacognitive competences is more efficient if working in groups, in a climate of cooperation and confrontation, because there is the possibility of mutual evaluation. In self-training, the individual student is more concerned about solving the problem itself, bout the acquisition of knowledge and s/he is less concerned by the understanding of how knowledge is acquired, how solutions were found or decisions taken.

Researchers have built a hierarchical model of the criteria-assessment questions in the classroom climate in function of different elements: diversity of awareness, respect for others' style, commitment, encouragement, student-teacher relationship, student-group-class relationship, learning with pleasure, and sense of humour, comfortable participation and freedom of expression.

Studies that explore the effects of attitudes and emotions on learning indicate that stress and constant fear, at any age, can circumvent the brain's normal circuits. A person's physical and emotional well-being is closely linked to the ability to think and to learn effectively [1].

2.2   The Instrumental Enrichment Program

The Instrumental Enrichment Program is composed of a set of exercises divided into 14 tools that are used as means for developing mental capacities. The exercises do not concern the acquisition of specific knowledge, but the acquisition of mental skills, of ways to use concepts in different situations [2]. Each instrument is focused on specific cognitive functions and provides means for developing cognitive capacities necessary for solving tasks that require a high level of abstraction.

The Instrumental Enrichment Program components are:
• Organization Points;
• Spatial Orientation I.
• Comparisons;
• Analytical Perception;
• Pictures;
• Spatial Orientation II,
• Classification,
• Temporal Relations,

- Instructions,
- Family Relations,
- Numerical Progression;
- Syllogism;
- Transferable Relations;
- Outlines.

The exercises have images and temporal relations that are organized differently and provide a gradual increase in difficulty. In this way the student is encourage to a progressive acquisition of skills necessary to solve the problems or tasks, thus strengthening motivation, the feeling of competence and autonomy in organizing intrinsic work. Subjects become aware of the importance and need for discussion about the work done and to make transfers on the basis of principles/rules/patterns formulated during activity. The development of principles/rules/patterns and the implementation of transfers are very important elements. All the details of the page of an exercise must be caught and analyzed and a synthesizing valid principle must be identified and expressed in a concise sentence. A principle is important because it can highlight a complex problem, newly learned information, or a necessary element to solve the exercise.

The transfer is created as a link between the principles/patterns/rules resulting from the reflection necessary for understanding and addressing new events [3]. During an activity, two or more instruments are used in order to avoid monotony of using for a long period the same type of exercises, or the feeling of failure resulted from difficulties in solving an exercise. Students are lead to use different instruments and to learn to choose the right ones. An activity is made up of elements called "pages". A page contains a story, illustrated by images. Each instrument begins with a picture page (cover or homepage), which is used for placing the instrument, creating a horizon for motivation and development through the following pages.

Any learning (instructional) form may be tackled from the point of view of the general systems theory, distance learning forms included. A system is defined by a set of elements that interact and work together in order to achieve an objective [7, 8]. Cover pages have certain features that remain unchanged from instrument to instrument to highlight the continuity of work, but each instrument is different from others. The mediator/trainer oriented subjects to consider the symbol on the cover to deduce the exercises that will solve the issues and that they will discuss.

2.3   Organize An Activity Of The Instrumental Enrichment Program

An activity of the Instrumental Enrichment Program is organized respecting some rules and some key moments: the introduction, individual work, discussion and conclusions [5]: In the following I will briefly present the key moments and the rules to follow.

Introduction. By going through this phase the mediator wants to awake the group interest in the work that will be developed and to define the problems they will have to solve. The introduction begins with revision, i.e. data from previous lessons. The mediator shall ensure that requirements and concepts were well understood, and that the vocabulary necessary to solve the task is assimilated. Students will learn to analyze the page autonomously. The trainer guides students in observing and identifying objectives [10].

Individual Work. In this stage students will be asked to solve an individual task, after which they will be involved in a discussion aimed at highlighting possible strategies for solving the exercises from the page. Students must understand that it is important not to finish quickly the exercises of a page. Is important to understand how to solve a task and how they form and develop certain abilities. An activity based on reflection, even if not fully effective, may be more useful, more fruitful than the one done in a hurry, because it is based on a more deep analyze the processes that formed it.

Discussion. When most students have completed the individual task the trainer may start the discussion stage. Being particularly interested in mental processes that led to finding the solution, it is appropriate to insist on correct answers and to explain the wrong ones, to understand the mental processes through which solutions were found [12]. At first it is recommended that the mediator identifies the link between work and other applied situations, then the students will gradually create these connections between the instruments and the surrounding reality. Each transfer is built on a solid and appropriate explanation of the type of connection between the examples and the proposed developments.

Conclusion. At the end of each lesson there should be a revision of the whole activity. Even if it is short it should highlight the steps taken to achieve the objective, the new words acquired, targets and strategies set out above for achieving the aim of the lesson. It is possible to encourage valorisation activities to determine individually or in small groups the utility obtained by applying different tools.

3   The Case Study

Development activities of the metacognitive skills students were conducted by applying the tools instrumental enrichment program developed by Reuven Feuerstein a group of 75 students from the Faculty of Engineering "Hermann Oberth", Section Computer Sciences, of the University "Lucian Blaga"

Principles: *One event can't be observed by itself , it has to be seen in the whole context, before and after. We have to make a difference between opened eyes dreams and reality, between what is possible and impossible. We have to be aware about our goals, about their importance and about the risks they implied.*

The 75 students have bee enrolled in a trening program aimed to develop their metacognitive skills. One group (40) has worked only in the classroom and one group (35) has used also the web based application designed to support them in developing metacognitive comptences. The web based application is preparing the student for the training program, the students becoming familiar with the kind of exercises used in the Fuerstein program.

At the end of the training program the overall scores of the students that have used also the web based application was significant higher than the score of the group that worked only in the classroom. Gender has not a significant effect on students' perception of their metacognitive skills.

A rather uncomfortable conclusion is that more than 75% of the students (no gender significant differences) have difficulties in expressing in words their thoughts and experience. The group that has a pre-training with the Cogitino web based application was significant more rapid in solving different tasks, but has the same difficulties in expressing in words their thoughts and experience as the control group.

4   The Web Application

In order to help students to better understand their thoughts and experiences a support software - Cogitino - has been designed and implemented. Cogitino is a web based application (fig.1) that offers a set of resources concerning meta-cognitive skills and acts as an adviser for the student that is enrolled in the metacognitive skills development training program. Cogitino is a multi-agent system (fig.2) that through its Profiler agent determines the student's level of meta-cognitive competences and then recommend different training paths (fig.3).

The system is rating students' metacognitive competences based on the answers to several questionnaires and problems' results.

Before applying the Instrumental Enrichment Program students are asked to solve several problems similar to those that they will have to solve during the class.

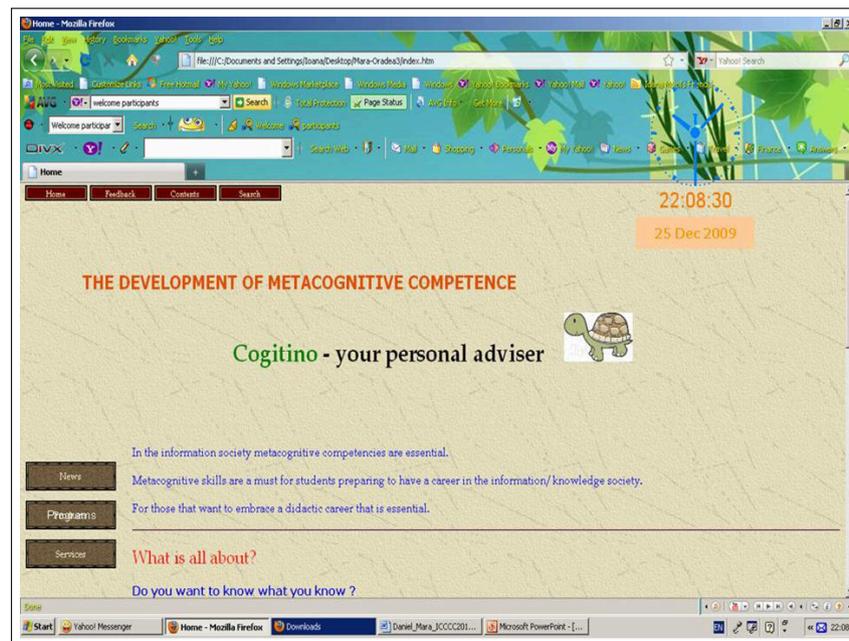Principle of e-learning applications have been observed [1, 7]
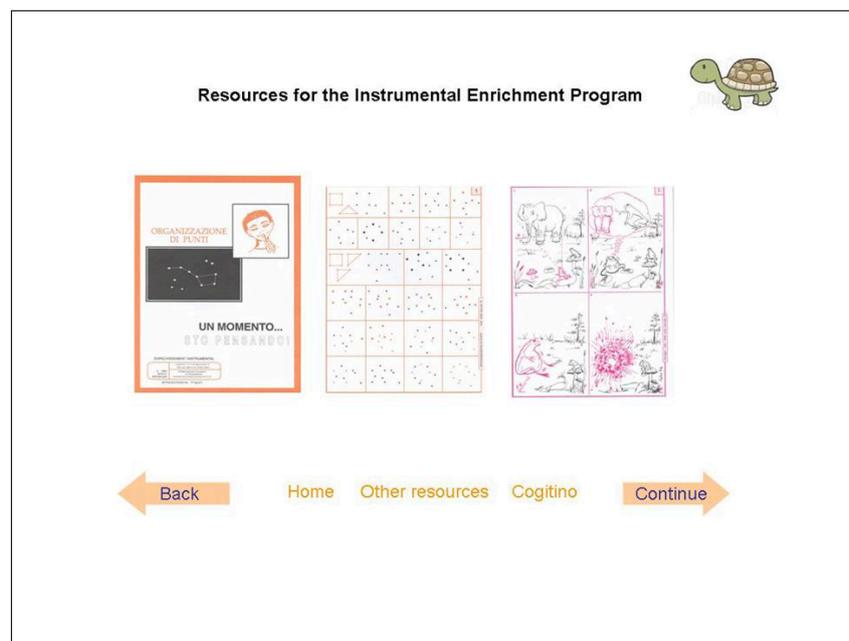

Figure 1: The Home page of the Cogitino application

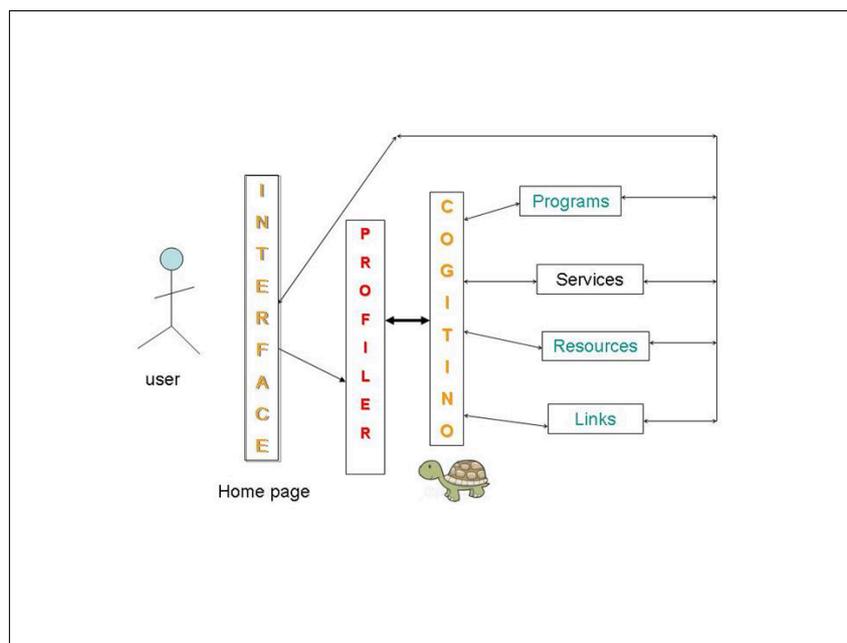Figure 3: Cogitino - Training resources

Figure 2: Cogitino - General structure

5   Conclusions

Metacognitive skills are mandatory for today students. They must be aware and must know their mental processes and they must be able to self-monitor, regulate, and direct their actions to their global aim. Metacognitive training becomes an important and basic tool also in business and management efficiency, skill and competences.

The result of the research carried out leads to evidence of at least three essential aspects in the development of students' meta-cognition competences. First, students balance their attention in preparation, implementation and evaluation of the educational and training process itself, but their qualitative analysis is poor. They have a reduce vocabulary and therefore a difficulty in explaining their experience and performance. Secondly, being enrolled in a technical program they feel, at least at the beginning of the training program, that they do not need to express themselves in words. And last but not least, the lack of general culture is an obstacle in understanding some of the tasks and problems they have been asked to solve. Meta-cognition components are usually observed only in the final stage of evaluation.

Another conclusion is that the web based application has been appreciated by students as very helpful. Considering this aspect and that in educational practice meta-cognition principles can be developed and applied efficient by students following a training program that included theoretical aspects and practical-application, my future work will consist in enriching (with the help of colleagues from the Computer Science Department of our university) Cogitino with two new modules : one module that will automatically generate explanations after a task has been solved, showing to the students how s/he has proceed, and another one that will be a "vocabulary training" for the student.

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