

# HOW TO IMPROVE METACOGNITION IN PRIMARY SCHOOL

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## Abstract

Educational and psychological research in the past decade has found that metacognitive capacity starts earlier than was initially realized; is more amenable to educational intervention than was previously thought; can be taught to a wide range of learners; and is both inherently contextual and a unique capacity that is distinguishable from intelligence, cognitive processes and motivation. In this paper we will see how metacognition can be improved in primary school pupils when teachers use instructional strategies that encourage meaningful learning, stimulate metacognitive reflection and provide continuous feedback. The purpose of this article is to explore the notion of metacognition with a view to clarifying its significance for the development of teaching and learning strategies that enhance pupils' capacities as autonomous learners. In particular, we propose three learning tools that, when used intentionally, can promote self-regulated learning: the concept maps, the assessment rubric and think-aloud method. We involved 45 students and 2 teachers (2 classes of fourth year of primary schools). The instructional and psychological foundations underlying these tools is briefly presented. The data available to date from a variety of qualitative and quantitative research studies strongly support the value of these metacognitive tools both for cognitive and affective gains. Metacognition is seen as facilitated through talk. The concept map produced in this research was analyzed using a qualitative content analysis, looking specifically for evidence of the process of text construction and metacognition. The issues provide evidence of young students' ability to engage in metacognitive talk and to use metacognition intentionally in the construction of concept map. Research has indicated that metacognitive instructional interventions make a difference in supporting the development of metacognitive knowledge in primary school children.

Keywords: metacognition, self-regulation, concept map, think aloud, primary school.

## 1 INTRODUCTION

Teachers know very well that pupils "learn to learn" by themselves, but they also know that specific trainings need to be realized in order to help pupils on learning self-regulation of their work. An instruction, generally described as "metacognitive" is needed since the first year of schooling. In the most recent Theories of Intelligence, metacognitive approach is considered fundamental for studying function of thought. It has been demonstrated that the metacognitive competence really allows pupils to be able to organize, direct and control their own mental processes, adapting them to task's needs; it allows construction of their own knowledge using cognitive strategies personally developed from the informations held. Pupils having a good metacognitive skills are able to recognize properly the difficulty of a task; they are able to ask themselves what they need to do; they are able to evaluate if planned strategies are fitting the task or not; they are able to think over what the learned and decide if it's relevant and compliant to task; they are able to schedule their available time among activities to do; they are able to know what expect as result of their efforts for studying.

In this paper we propose three methodological procedures, tested in four fourth year of primary school in Palermo, which can help to develop students' metacognitive reflection and self-regulated learning: the construction of concept maps, and the reasons for the procedure chosen; the construction of rubrics for self-assessment, with its criteria and indicators, and the teacher-pupil dialogue aimed make explicit mental process carried out by the pupil to solve the task assigned. The autonomy of the person grows with exercise on capacity that everyone has on thinking in a metacognitive way. The metacognitive competence should be promoted and enhanced by anyone who plays a role in school education. Therefore, helping pupils to reflect on their learning and, above all, encouraging them to make the best of their intellectual resources is a fundamental element for the success of the teaching-learning process. The major advantage of training pupils how to self-regulate their learning in the beginning of their schooling is that during these first crucial years, students set up learning and self-efficacy attitudes [1] which are easier to change than when students have already developed disadvantageous learning styles and learning behavior [2].

## 2 THEORETICAL BACKGROUND

A feature that links intellectual abilities to metacognition refers to how mind controls itself and reaches to self-regulation<sup>1</sup>. On learning, during the adapting to new situations process, an important function is the pupil's self-regulation on accomplishing the task and achieving the goal, i.e. in putting into practice appropriate strategies that allows intellectual abilities to realize an exchange with the environment, acquiring knowledge and expertise. Self-regulation is considered as a key mediator between own mental capacity and own acquisition of academic skills [3]. The self-regulated learning is an important predictor of academic achievement, and requires the students the ability of planning independently, of monitoring and evaluating their own learning. It's a process that grows gradually. There are few pupils that, spontaneously, succeed well in this task and the transition from hetero-regulation to self-regulation requires a specific aimed action of the teacher: on helping pupils on improving their learning habits and on strengthening their skills on studying [4]; on concretely applying learning strategies to improve educational outcomes, to monitor their own performance [5]; on assessing their progress in studies [6]. The instructional interventions carried out in the classroom by teachers to promote self-regulation of learning are useful not only for academic performance and the use of strategies, but also affect the motivation of pupils [2]. It is appropriate, therefore, that teachers are familiar with the factors that influence the ability of a student to self-regulate and the strategies they can use to promote and strengthen the self-regulated learning in their classrooms.

A recent research [3], made with the intent to identify the most effective educational interventions for the promotion of pupils' self-regulated learning, has shown that the performance of pupils in primary school improves when teachers use both strategies able to encourage meaningful learning, and strategies to promote metacognitive reflection, and instructional strategies that provide continuous feedback. The most significant improvements in self-regulation on learning were obtained when the students have acquired and applied the strategies of metacognitive reflection intentionally proposed by their teachers. The research on instruction of self-regulated learning has revealed the gain of implementing these training programmes directly in classrooms [2]: first, strategy instruction should be context-related which is easier to attain when embedding it in regular instruction. Empirical studies found that training programmes are more efficient if students are learning domain-specific content and, in addition, strategies to handle this content competently so that both can be related to each other [7]. Second, training programmes should also create learning environments that are conducive to self-regulated learning, so that students are provided with opportunities to apply and practice the newly acquired strategies [8]. Third, in order to enhance transfer of self-regulated learning to other areas even contextualized forms of strategy instruction need to address the issue of transfer directly [9].

### 2.1 Concept mapping

The application of concept maps has proven effective in different fields: helps students to learn and teachers to design and evaluate; helps managers to better plan and manage their own business organization, helps researchers and scientists to organize and to analyze their own scientific activity. Using concept maps at school performs a double function: on one hand can be used for the organization of the curriculum, in order to identify and highlight the concepts that guide the teaching and the connections that bind them; on the other hand they are configured as an opportunity to facilitate the acquisition of meaningful learning in students and to promote the cognitive and metacognitive enhancement. In this perspective, the effectiveness of the tool occurs when students are trying to organize their knowledge independently and they compare and discuss this knowledge with their peers and with the teacher.

For over thirty years research on teaching has shown that the use of concept maps is configured as an effective strategy for meaningful learning [14] in students of all age groups and in different sectors or learning. Meaningful learning is facilitated because the concepts are not seen as isolated entities, but as elements in a network of relationships. Meaningful learning involves the learner's effort and his will, and for this reason, we believe that meaningful learning and self-regulated learning are mutually postponed, contributing to the harmonious development of the whole person.

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<sup>1</sup> This work has been inspired by two traditions within developmental psychology: the cognitive information-processing tradition represented by the early work of Flavell [10] and Ann Brown [11], from which the term 'metacognition' emerged, and the socio-cultural tradition founded on the work of Lev Vygotsky [12] from which the term 'self-regulation' derives. This second conception has become increasingly dominant in the literature and is broadly the model we have adopted within the present study, with metacognition forming the cognitive parts of self regulation, which also encompasses affective, motivational and social elements [13]. However, we have used both terms to recognize those parts of our model of self regulation which draws heavily upon the cognitive tradition.

To help students to learn in a meaningful way it is necessary that the teacher clarifies the role of the concepts and the relationships between them, in order to facilitate a comparison of the concepts that are in their minds and those that exist in reality or in texts. The concept mapping allows pupils to extract concepts from specific materials written or oral, in order to identify the relationships between concepts. This requires to isolate concepts and link words, that are important components of language. When a student achieves a conceptual map makes explicit the concepts and propositions that owns and, at the same time, performs a creative activity, because in building propositional networks around the concepts is encouraged to recognize new relationships and hence new meanings [15]. Explicit teaching for using strategies is an effective means to promote self-regulated learning [16] which, as we have already had occasion to explain, refers to the degree to which students are actively involved in their own learning process from the metacognitive point of view, motivational and behavioral. Teaching to design and create concept maps helps pupils to participate in activities, to maintain focus on the most important features to organize the material and maintain a productive climate for learning [17]. It has been suggested that the most appropriate time for introducing mapping may be early in the students' educational careers, before preferred study habits have been firmly established [18].

## 2.2 Rubric

A method for promoting the development of intellectual abilities and metacognitive competence in the students is to ask them to evaluate their own work. Pupils evaluating their own work will be able to identify areas that need improvement [5] [19]. In this sense the rubric is set up as an effective tool. Rubrics were created as tools to assess the quality of products and performance in a given area and increase, later, as a tool for authentic assessment. In the last decade, the scientific literature has pointed out the importance and effectiveness of the tool not only for assessment but also for teaching and learning [20].

Rubrics were created to evaluate the work of the students, but since time now many researchers have argued that they may also play a different and more important role: in addition to assessing, rubrics can also teach. Involving students in the assessment process, teachers are able to eliminate the distinction between education and evaluation, transforming the assessment in a time of learning. Stiggins [21] argues that, if rubrics are used as part of an evaluation approach focused on pupils, they are able both to help the students themselves to develop understanding and intellectual skills, both in making a good judgment about the quality of their work. Dignath and his colleagues [2] have demonstrated the importance of help pupils develop self-regulation in the early school years, that is an essential skill for success in subsequent educational levels. They have also shown that it is important to work on it before students to start on developing their performance and avoid behaviors that have a negative effect on their learning. These studies have shown that the teacher's interventions to promote self-regulated learning when they are focused mainly on performance control stage (through monitoring) and on self-reflection's stage (through the self-assessment), they lower influence on self-regulation, compared to those interventions that involve, along with the other two, even the prediction phase (through planning and goal setting). This difference can be explained considering that the self-assessment involves a judgment on own performance based on criteria previously established in a more or less conscious way [22].

These assessment criteria must be explained to the students at the beginning of their learning process, so that the student can have the same expectations clear on the goals and plan accordingly actions to be taken. In other words, the intentionality of a training program intended to promote self-regulation in the student through the proper use of an assessment rubric, it must be made clear at an early stage of prediction. We have already pointed out in the preceding paragraphs as rubrics are able to produce effective results for the purpose not only of learning, but also of self-assessment and then, if they are included as part of an overall design and if they are supported by structured interventions; instead it was shown that their simple submission is not guarantee of success. A recent study [22] has shown that the rubric is an effective tool for improving the proficiency in the performance of a task by the students, as it includes and makes explicit the factors relevant to the task. This same research has shown that when the use of rubrics is joined by teachers' feedback focused on the process, there is a significant increase of self-efficacy perceived by the pupils, a factor which in turn positively influences self-regulation. This result is due to the union of the clarity of the criteria related to the performance provided by the book with the teacher's feedback focused on the process. The combination of these two types of information helps pupils to face efficiently at the various learning tasks.

### 2.3 Assessing metacognition with the think-aloud method

To promote the intellectual and metacognitive skills in the students and to develop their self-regulation, the construction of concept maps, as well as the use of the rubric, are presented as necessary but not sufficient. These actions should be initiated, supported and complemented by a continuous dialogue between the teacher and his own students, because it is through the practice of discussion that the reasoning is manifested, structured and explicated. The discussion in the classroom between teacher and pupils, aimed at strengthening their own self-regulation, it is essential for the acquisition of new knowledge and strategies more complex. Through interaction with the teacher, pupils develop processes and strategies both of learning both of metacognitive reflection. Through the intentional dialogue in the classroom, the students may be asked to reflect systematically on own knowledge, on own learning strategies, on own cognitive and metacognitive processes [23]. In the report of communicative exchange, the teacher assumes the role of guide, seeking to bring out what the student already owns unknowingly and guide him to discover himself. The discussion allows the teacher to identify the zone of proximal development of the pupils and to intervene promptly. Thanks to the identification during the discussion of ideas of the student, correct or wrong, it is possible for the teacher to act to orientate his learning process and to effectively incorporate new knowledge, linking it to his own knowledge, in order to facilitate a meaningful learning.

How to measure metacognition accurately has long been an issue of concern. Although a number of self-report measures of metacognition have been developed, they bring along problems such as participants failing to recall a cognitive process and failing to be aware of how the cognitive process relates to their thought products. Such problems hinder the validity of the data that we gather, as metacognitive activities are being assessed before or after the thinking process rather than during the process. Other suggested methods include examining verbal reports, eye movements and underlined text. Similarly these methods disallow individuals' actual thought processes to be revealed and followed through. In fact any non real-time measurement that requires participants to recall their cognition after task completion would give an incomplete picture of the actual thinking process [24].

Verbalization methods are the only ones that allow a glimpse into the participant's mind during learning, whereas data from eye movements concern behavior and, thus, the cognitions and metacognitions underlying the behavior have to be interpreted by the researcher. Veenman [25] classified metacognitive skill assessment methods as off-line and on-line methods. Depending on the moment they are conducted, he distinguishes off-line methods, which are performed prospectively or retrospectively to learning, from on-line methods, which are conducted concurrently during learning. Prospective and retrospective assessments are usually obtained by questionnaires and interviews and often fail to predict learning outcome. Therefore, for assessing metacognitive skills in particular, he recommends on-line methods, which are more accurate and valid [26].

Among the various methods suggested, the think aloud procedure, wherein participants are asked to say aloud everything that goes through their mind while completing a task, has drawn positive attention. Ericsson and Simon [27] argue that compared to other verbal reports, asking participants to verbalize thoughts during a task reflects thinking processes more directly. It has been considered a very direct method to gain insight into the knowledge and methods of human problem solving, and it offers a way of accessing rich information that is unattainable through other means. Concerns have been raised regarding whether the process of thinking would be interrupted, altered or incompletely reviewed under the think aloud procedures. Ericsson and Simon [27] argued that verbalizing one's thought would not alter the course of thinking nor would it affect the nature of the on-going cognitive activities, as the procedures do not involve participants interpreting their own thinking. Hence, think-aloud protocols are considered reliable because thinking aloud takes place almost simultaneously with the thinking process which allows thinking activities to be closely followed while keeping the risk of losing information minimal.

A think-aloud protocol involves students' reports about their thoughts and cognitive processes while performing a task [28]. Thinking-aloud protocols are considered a good representation of the self-regulatory actions and metacognitive processes of students during an activity [27]. Thinking aloud protocols may be useful for teachers to help pupils to control their processes of self-regulation, to identify which strategies and which processes are most likely to succeed in certain learning tasks, to gain valuable insight into the way in which the students interpret the assigned task and the process knowledge, to understand the causes of success and failure at school [29].

### 3 THE OBJECTIVES AND HYPOTHESIS OF THE RESEARCH

Basing on reflections about results of the research, described above, three possible teaching methods capable of promoting self-regulated learning have been speculated, because significant. It is believed that the student decides to self-regulate his own learning when he captures the subjective significance of the proposed teaching of his teacher. Once the significance of the learning task for the pupil has been ascertained, we can choose the methods and tools that support the development of the ability to self-regulate their own learning: the concept maps, self-assessment rubrics and think aloud method. With a specific training activity it was intended to foster and develop in the primary school pupils (age 9) related skills to self regulated learning and metacognition. In particular, it was assumed that if the educational activities had been well designed and realized, each pupils, in addition to what he learned about discipline, he would have achieved a significant improvement of metacognitive skills.

### 4 THE RESEARCH

The training was aimed at the acquisition of metacognitive skills through the use of three different tools: the concept maps, rubrics, think-aloud method. The training process involved two classes fourth grade of primary school in Palermo for a total of 45 students and 2 teachers. During the course of experimental teaching were conducted weekly meetings with the teachers of the 2 classes in order to supervise and monitor the training activities. We have experienced a training process aiming to pursuing the overall objective of improving metacognitive skills of students in the normal course of teaching activities. The training process lasted a total of 10 hours and was divided into five steps: (a) the introductory phase; (b) the training phase; (c) the test phase; (d) the self-assessment phase; (e) the formative assessment phase.

*Introductory phase.* In the beginning, before the realization of the map done by the pupils, the teacher led a conversation with class group to detect the cognitive matrix. The mode of lead the conversation in the involved classes was collective and focused both on specific subject content (physical geography of the rivers), and on the methodology for the implementation of the concept map. Teachers have preliminarily: encouraged the students to feel free to express their ideas about the topic; organized the space of the class in order to facilitate the exchange of communication; prepared the tools to record the conversation. Teachers, before starting conversation, they have created a positive atmosphere. In particular, they motivated the activities that the students had to perform, assigning to themselves the role of the teacher who "does not know " and therefore poses questions to his students to learn. After fulfilling these pre-conditions, the classes have been asked with questions-stimulus related to the concept map: "Have you ever heard of the concept maps?", "What is a concept map for you?", "Why you could build a concept map?", "What can be discovered through a concept map?", "What are the characteristics of a concept map?". The questions of the teachers are addressed to identify and detect the concepts held spontaneously by students on what is a concept map. At this stage teachers have listened carefully to the organization of the knowledge of their pupils and leaded the conversation, verifying the spontaneous concepts held by them. During the conversation, the teachers asked questions-stimulus and questions-specification. To grasp the processes of conceptualization teachers do not have lined up and tried to "recover" the actions of all pupils to foster a climate in which the different points of view were welcomed and appreciated. At the end of the conversation they have synthesized with the students all the ideas generated, recalling, if needed, the questions that found no answer.

*Training phase.* Participants were trained to create a concept map about rivers. Since the structures of the conceptual map depend on the context in which they are used, to teach pupils to IV primary how to build a concept map it was decided to start with a domain (content) of knowledge (water streams) that were familiar to pupils. The content that is the domain of the map is selected from the textbook in use in the classroom. During this step, to define the context for a concept map, teachers asked to pupils a question able to clearly focus the problem, that is the question to which we try to give the answer through the construction of the concept map. Specifically, rather than asking "What are the rivers" or "Why rivers exist?", Teachers asked their pupils following question "Why do we need the rivers?". After they have selected the domain and defined the related key question, the following step was to identify the key concepts that are related to the determined domain, giving pupils a predetermined list of 5 concepts. Then, the teachers asked their students to identify 15 further concepts, to list them and establish an ordered list placing the most general and inclusive concepts at the top, and the more specific ones at lower level. In the construction of the concept map pupils, with the help of the teacher, were asked to formulate objectives related to the task they were performing (defining the research

question, identifying the concepts, making the connections, etc..). Since research [30] has shown that when the short-term goals are integrated with long-term objectives in a hierarchical system, the use of the processes of self-regulation on the part of pupils continues over time, teachers task was to highlight the link of the specific objectives with the overall objectives, in order to show the intellectual abilities related to these same goals. In this way, the focus was not directed exclusively on the product (the complete map), but it was oriented to the improvement of own learning and own intellectual abilities (induce relationships, build classrooms, build concepts and categories, express an opinion). Teachers have encouraged the students to plan the task asking them to specify when, where and how their answers could lead them to the goal. During the realization of the maps, pupils rather than simply point out a goal that was expressing their intention ("I want to complete the map", "I want to make connections between concepts"), were stimulated to connecting directly the expected situations with the direct answers to goals ("When I will have formulated the key question, I will be able to identify the individual concepts").

*Test phase.* At this stage, 45 students were asked to draw independently a concept map on mountain ranges. The task given to pupils was similar to that of the training phase. Also in this case it is a familiar content for pupils, selected from the textbook in use in the classes. Differently than in training phase, teachers had a more defiladed role and stimulated pupils to think aloud while going on with the task execution.

*Self-assessment phase.* In order to evaluate the concept maps of the students and, at the same time, to stimulate reflection on their own learning process has been used an assessment rubric constructed ad hoc with the teachers<sup>2</sup>. By sharing a rubric with the students, teachers can help them to become progressively more aware of their performance and more attentive to the processes put in place while they are doing, because it allows both the teacher and his pupils, to identify and clarify the specific expectations related to the tasks and it indicates how pupils achieved the objectives set. For this reason the rubric must be thoroughly presented by teachers to pupils and it must be left to them, one for each student, during the concept mapping to help them understand the objectives of the task and to teach them how to self-head in the concept mapping. It was decided to put the focus on the three peculiar evaluative dimensions that characterize a concept map: (a) the processing mode of the concepts, (b) the organizational and structural aspects of the map, (c) the skills and metacognitive strategies involved in a concept-map's construction. Each of the dimensions was subdivided into specific criterion. We defined 16 criteria deducing from the research [2] [15] [31] [32]. The criteria indicate the goals and objectives to be achieved and they are also useful to determine when they are achieved. It is essential to explain the criteria to involve pupils in their assessment of concept mapping. Then it was identified for each criterion an indicator.

*Formative assessment phase.* During the test phase, the method of thinking aloud was used. Instructions for thinking aloud were carefully constructed following recommendations by Ericsson and Simon (1993). Pupils were instructed to say whatever came to their mind as they carried out the tasks, without first judging the relevancy. Instructions were as follows: "While you are working on the concept map, please verbalize all your thoughts. Just speak out whatever comes into your mind, no matter what it is." When pupils stopped verbalizing for more than 20 s, they were prompted to continue ("Please keep on talking"). Empirical evidence suggests that this type of verbalization instruction is least obtrusive to participants' cognitive processing [23].

## 5 DISCUSSION

*Rubric analysis.* The rubric for the students had the function of a prompt capable of fostering the following important functions: focusing attention on the task, stimulating prior knowledge, enhancing comprehension, monitoring thinking, facilitating concept mapping processes. Each indicator has been declined on a four level scale (High Proficiency -4, Proficiency -3, some Proficiency -2, no/limited Proficiency -1/0), which specifies indicator achievement degree based on an ordinal scale that goes from the highest level showing the full achievement of the indicator, to the lowest indicating the minimum requirement for success. In the next table, a summary of the rubric is presented, followed by the frequency of the scores that each student attributed to himself.

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<sup>2</sup> In addition to refer to the procedure and general guidelines for the construction of a rubric, we have identified the constitutive dimensions of the rubric, that we wanted create, after reviewing the previous concept maps made by our own pupils, as result of the theoretical indications on the object "map", existing in the literature. Once the size was defined, teachers have identified indicators and related criteria. Each indicator has been listed on a scale at multiple levels, specifying the degree of achievement of the considered criteria: from the highest level (indicating the full achievement of the goal criterion) to the less high (indicating the minimum requirement for success).

Dimensions: Processing of concepts	N=45	4	3	2	1/0
<i>Relevance to the domain</i> In the map, I answer to the initial question.		3	38	2	2
<i>Completeness of map</i> I develop a map using all the concepts of the list.		7	21	13	4
<i>Variety of connections</i> I put more links on the same node.		6	19	15	5
<i>Originality</i> I perform significant cross-connections.		9	24	10	2
<i>Strutturazione logica dei concetti (comprensione)</i> I organize the map according to a hierarchy (the map is not in sequence). I insert in a proper manner the linking words on the "lines" of my own concept map. I put the result of an event after its direct causes. I correctly identify the main concepts.		10 10 8 13	28 25 31 22	3 6 4 6	4 4 2 4
<b>Dimensions: Organizational and structural features</b>					
<i>Implementation of the list of concepts</i> I draw or complete the list of concepts, avoiding synonyms of the terms and the use of an entire sentence to explain a concept. I prepare or complete the list of concepts by keeping them separate from the linking words.		9 12	24 21	7 8	5 4
<i>Order of concepts (hierarchical structuring of the map)</i> I sort concepts from the most inclusive to the less inclusive. I set close together concepts that are closely related to others, to avoid that the links that connect them intersect other already previously drawn. I set the concepts in such a way that the under-ordered concepts are more specific than concepts placed in position the higher-order.		10 9 10	30 31 29	2 3 4	3 2 2
<i>Link between concepts (linking words)</i> I explain the relationship between two concepts with connecting lines marked with words. I identify a valid relationship between concepts. I'm very accurate in identifying the linking words between concepts.		15 11 11	24 28 23	4 4 6	1 2 5
<i>Link between propositions (cross-linked)</i> I'm very selective when identifying cross-links. In the map, I highlight significant connections between a segment of the conceptual hierarchy and another one. I identify valid cross-links. I identify significant cross-links.		8 7 9 9	27 23 25 21	6 10 8 9	4 5 3 6
<i>Examples</i> I report events or specific objects, shown as examples given of mentioned concepts.		12	22	7	4
<b>Dimension: Skills and metacognitive strategies</b>					
<i>Motivation effort</i> I draw up a map correctly and completely, even when I'm not interested on topics		13	21	6	5
<i>Meta-comprehension</i> When creating the map, I try to clarify myself the targets of his work.		9	29	4	3
<i>Self-regulation</i> When correcting a part of the map, I check if the fix is compliant with the other parts		8	27	7	3
<i>Self-assessment</i> I assess my own conceptual map relative to the goal I had set for myself		12	23	6	4
<i>Planning</i> I create the map in relation to a fixed target and taking care of the right purpose		14	21	5	5
<i>Revision</i> The map shows different revision marks (eg. erasures, self-corrections)		28	10	4	3

The data resulting from self evaluation of the pupils through their rubrics in addition to confirming the previous findings, give us more information about the processes and metacognitive strategies put in action by the learners during the process of concept mapping. The rubric, which takes into account multiple dimensions simultaneously, allowed teachers and their students to pay attention not only to the structural characteristics of the map (immediately visible), but also to the cognitive and metacognitive processes that are triggered when the student is involved in the realization of the map itself.

*Think aloud protocol analysis.* Thinking-aloud protocols, along with the teacher's notes on non verbal aspects of performance, were recorded and later analyzed using the content of each complete proposition (i.e., stand-alone idea) as the unit of analysis. The protocols are then segmented into units for analysis, coded with a category system following from the construct definition and the logical analysis of the assessment demands and category frequencies counted and reported along with supporting quotes from protocols. Our coding system comprised 12 distinct categories (Hilbert, Renkl, 2007; Ku, Ho, 2010):

Categories	Description	f	%
1. Planning	Comments on preparation for task execution. The pupils inquires about or identifies procedures and requirements of a task: both indicating an awareness of the need for planning; both specifying actual planning action.	258	14,08%
2. Monitoring	Comments related to task comprehension (both comments indicating the need to check for one's understanding; both comments clearly pointing out known or ambiguous information). The pupils check or points out own understanding/lack of understanding as well as know/unknown information.	218	11,90%
3. Evaluating	Comments representing assessments of own thoughts and performance in relation to the task goal. The pupils indicates recognition of a problem or a error.	247	13,48%
4. Other self-regulatory propositions	Content referred to questions asked while receiving instructions, or included messages for controlling disturbing emotions, help-seeking, or revision, and questions of clarification during feedback.	196	10,70%
5. Understanding (negative monitoring)	This category contained utterances about comprehension problem.	107	5,84%
6. Understanding (positive monitoring).	The learner stated his or her understanding of the contents.	169	9,22%
7. Elaboration of concepts	The pupils connected his own knowledge with the learning content by generating examples or paraphrasing.	212	11,57%
8. Relevance	This category was coded when a statement referred to the importance of a concept.	107	5,84%
9. Relationship	The learner clarified the relation between concepts by thinking about how to label the links, by using colors, or structuring the concept map in a way that accentuates groups of concepts.	127	6,93%
10. Descriptive propositions	The content refers to what the pupils was observing while concept mapping.	71	3,88%
11. Non content problems	The learner talked about general problems with the mapping method, or the demand of thinking aloud	102	5,57%
12. False statements	Incorrect statements of the pupils were coded in this category	18	0,98%

Two researchers classified all the propositions independently according to the 12 categories seen above. The 45 protocols were independently coded blind for each pupil. Initial percent agreement was found to be 89% (Cohen's kappa.87, based on a subsample of 1.832 segments). Disagreements were then sorted through by discussion between the coders. If a statement was categorized as metacognitive and the same statement was then merely repeated by the same pupils, these



repetitions were counted as such and excluded from further analyses. We calculated the percentage of metacognitive statements relative to the total number of statements (1.832) to represent metacognitive activity during training: the sum of the first six categories listed in the above table shows that 65.23% of the students' statements refer explicitly to the metacognitive skills.

## 6 CONCLUSIONS

It is necessary, in the school practice, to identify what allows the student to perceive himself in a realistic way, to increase his desire to learn, to learn how to self-regulate his own learning. In order to promote self-directed learning is essential to focus on the processes of self-regulation and devote time and effort so that the students learn to learn. Research has shown that learning to learn is not equivalent to acquire specific skills for the study, but consists of being really able to organize, direct and control the mental processes, to adapt them to the needs or to the task and to effectively control own will. In the previous pages the concept maps, self-assessment rubrics and think aloud method, have been seen potentially playing a very powerful role in promoting meaningful learning and providing the teacher with a valuable insight into the mental models of students. This has enabled teaching to be more precisely focused on the students' needs and so make more effective use of class time.

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