Effects of an Intervention Programme for the Development of Metacognitive Skills in Secondary School Students

Natalia Larraz Rábanos* and Pedro Allueva Torres

Facultad de Educación, Pedro Cerbuna, 12, 50009 Zaragoza, Universidad de Zaragoza, Spain

Abstract: The aim of this paper is to present the results of an intervention programme for the development of metacognitive skills applied to a group of lower secondary education students at a school in Saragossa (Spain). The programme consisted of nine structured sessions carried out over a period of seven months. The study used a repeated measure quasi-experimental design with a non-equivalent control group. The sample included 45 participants aged 13 to 14 years. ANOVA results showed significant metacognitive skill development in the experimental group and non-significant metacognitive skill development towards significance between the two study groups. To improve the results of the programme, the generalisability theory was applied, which suggested the programme was effective, despite the need to increase the number of exercises to improve the intervention, to obtain significant results thereafter. The conclusions of this paper point out that if metacognitive thinking skills development is incorporated into teacher training processes and into teaching-learning processes, secondary school students' learning improves.

Keywords: Metacognition, Metacognitive judgements, Thinking skills, Intervention programme, Secondary education.

1. INTRODUCTION

The development of metacognitive skills has clearly become essential to achieving a higher level of learning and education. Therefore, it is suggested that metacognitive skills be introduced into the curriculum and objectives of educational systems to achieve more effective learning standards and a high-quality teaching-learning process.

The concept of metacognition, which involves learning how to learn and learning how to think through awareness and taking control of one's own knowledge and learning processes, gained importance as a consequence of Flavell's work [1]. Metacognition has been defined as "cognition about cognition" or "knowing about knowing" and, according to Brown [2], as the ability to know and regulate one's own cognitive processes. Today, international and European educational policies consider the development of metacognition as an objective of the educational curriculum through the acquisition of key competencies such as *learning to learn*, as recommended by the European Parliament [3]. Educational efforts should, therefore, be directed at promoting and developing effective cognitive strategies and adopting a methodology that encourages learning and student motivation to improve academic performance and prevent school failure.

Most authors agree that higher-order thinking implies metacognitive thinking as a core skill of human cognition [4] and as one of the major components of cognitive development [5, 6] involved in the improvement of learning and cognitive performance [7-10]. More specifically, the incorporation of this skill into secondary education is recommended because several studies show that, in this stage, students develop higher levels of cognitive and metacognitive thinking skills, which leads to more advanced thought processes and reasoning [11, 6].

Despite the importance of metacognitive skill development, educational efforts in this direction are limited. Research results indicate a moderate use of metacognitive strategies in secondary education and suggest that the extent of implementation could be enhanced if the use and acquisition of these strategies in the classroom were intentional and explicit [12, 13].

Many authors suggest a distinction between two fundamental properties of metacognition: metacognitive knowledge, which is knowledge of our cognition, and metacognitive skills, which is the regulation of our cognition [14, 15]. According to Brown [2], we must ensure the proper development of metacognitive skills during the learning process, which takes place before, during and after the performance of a cognitive task. In addition, learning involves the use of numerous self-regulatory processes such as planning, knowledge activation, metacognitive monitoring and regulation and reflection [16].

According to Brown's theory [15], metacognitive knowledge is relatively stable, fallible and verifiable, and metacognitive skills that involve regulatory processes (planning, monitoring and evaluation) may

*Address correspondence to this author at the Facultad de Educación, Pedro Cerbuna, 12, 50009 Zaragoza, Universidad de Zaragoza, Spain; Tel: (+34) 976761304 - Ext. 844832;
E-mail: nlarraz@unizar.es

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not be conscious or stable in many learning situations because they depend on context and are highly automatised. Many of these processes are developed without any conscious reflection and are difficult to report to others [17]. Based on this assumption, metacognitive skills are more easily developed and can be used to effectively develop a body of metacognitive knowledge.

Metacognitive skills are normally developed during the self-regulatory processes involved in learning. Self-regulation refers to self-generated thoughts, feelings and actions planned and critically adapted to the attainment of personal goals [18]. Several authors [19] have studied the development of students' self-regulatory processes and the self-regulation of learning, and research has established that self-regulatory processes (goal setting, self-monitoring and self-evaluating) are highly predictive of students' achievement in school and in their learning. Furthermore, there is evidence that students who self-regulate their goals and self-monitor their attainment of those goals are more likely to attribute their outcomes to personally controllable strategies than students who fail to self-regulate [20]. Kruger and Dunning [21] showed, across four studies, that metacognitive skill is based on the calibration skills or the capacity to distinguish accuracy from error when performing the task. This calibration skill allows improving the metacognitive competence of the participants by helping them to recognise the limitations of their abilities. They also argued that motivation and metacognitive judgements are related to metacognitive skill.

Noël's [22] theory is based on the hypothesis that the development of metacognitive skills is achieved through the metacognitive judgements of one's performance regarding the quality or the products of mental activities that are not usually specified. These judgements may modify cognitive activity due to the situation that caused them. Therefore, it is assumed that metacognitive skills are acquired through using metacognitive strategies and acquiring appropriate metacognitive judgements and that their use and frequency will determine the appropriate acquisition of metacognitive knowledge [23, 24]. Thus, metacognitive skills are developed in the moments following the performance of a task: 1) Before performing a task, we should apply prediction and planning skills; 2) During the performance of a task, we should apply regulation and control skills and; 3) After performing a task, we should apply verification skills.

In light of the research findings outlined above, the study presented here consisted of the design, implementation and evaluation of a programme for metacognitive skill development based on improving the accuracy of metacognitive judgements issued by a group of 13–14-year-old lower secondary school students (Level 2) (UNESCO) [25]. This study examined how metacognitive skills can be developed if students make accurate metacognitive judgements before, during and after the performance of academic tasks. This programme proposes a problem-solving model based on metacognitive thinking skill development in which metacognition is established as a core skill that guides other cognitive processes [26].

2. PARTICIPANTS

Forty-five pupils at a Spanish secondary school, ranging from 13 to 14 years old (M = 13.36 ± 0.48), volunteered to take part in this study. Participants were randomly placed into either the experimental or control group. Thus, there were 21 participants in the experimental group (M = 13.02 ± 0.58), 11 males and 10 females, and 24 participants in the control group (M = 13.17 ± 0.38), 13 males and 11 females. The attrition rate of the study was 6%, due solely to the experimental group. The sample size was determined by considering the power required to detect a moderate size effect (f^2 0.15) with the alpha set to 0.05. Prior to data collection, ethical approval from the institutional review board was obtained, and professional body guidelines were adhered to.

3. MEASURES

Before and after the intervention was administered, participants completed the Noël [22] metacognitive skills questionnaire, which was adapted by Allueva [23] for the pretest and the post-test and by Larraz [24] for the follow-up test. Both groups then completed these three questionnaires before and after the experimental group had experienced the metacognitive intervention. Responses consisted of ratings made on a scale of 1 to 3, where 1 represents poor progress and 3 represents good progress in metacognitive judgement accuracy.

The Noël (1991) metacognitive skills questionnaire is based on encouraging and promoting the acquisition of metacognitive skills by issuing metacognitive judgements on one's task performance before, during and after a task. This questionnaire considers three stages of the metacognitive process during the performance of a cognitive task (see Figure **1**) and asks two types of

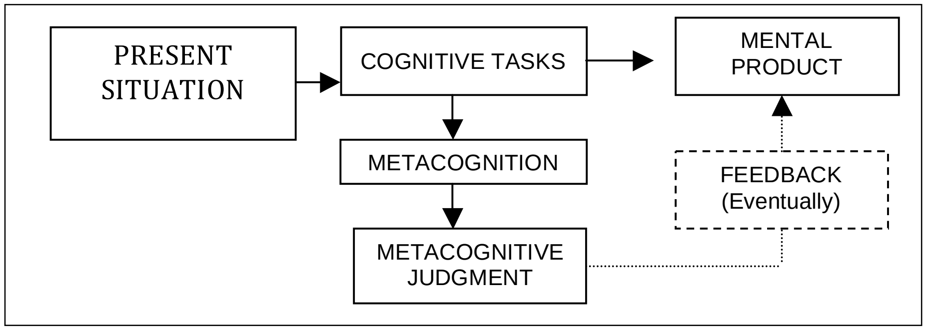

Figure 1: Noël's model of metacognition (1991).

questions about task performance: 1) Metacognitive judgement questions that reflect two different types of metacognitive judgement (before the task was performed): a) *Have I understood?* (*Abstract Metacognitive Judgement*; it refers to *Abstract Metacognition)*; b) *Could I do or solve it?* (*Operative Metacognitive Judgement*; it refers to *Operative Metacognition)*; 2) Metacognitive decision questions that can reflect a person's decision that depends on their metacognitive judgements (can or cannot modify the activities or the mental product of the situation after the task was performed): a) *Do I believe that I am successful?* (*Confident Judgement* about the answer); b) *Should I change my performance? (Regulatory Metacognition,* regulatory actions). These questions refer to *Regulatory Metacognition* (mental activity involved in the decision process based on metacognitive judgements regarding own performance).

4. PROCEDURE

The metacognitive intervention was carried out by a PhD student of psychology and a secondary school teacher. The teacher was previously trained on the intervention requirements. The intervention incorporated a series of stimulating and motivating exercises **–** over eight sessions lasting 50 minutes each **–** to develop metacognitive skills with respect to open and closed problems in a specific and a non-specific domain. The sessions consisted of applying a number of exercises that were implemented through individual and group work in the classroom.

During the exercises, the participants had to solve open and closed problems based on academic tasks and had to answer self-instruction questions about their own performance judgements. These questions were asked before (e.g. *Have I understood? Could I do or solve the problem?),* during and after the task performance (e.g. *Do I believe that I am successful? Should I change my performance?*). Once the problems were solved, they were corrected; thus, the students received immediate feedback on the accuracy or the lack of accuracy of their performance. Judgements were assessed using Likert-scale questionnaires during problem solving to observe and follow up the implemented programme and monitor the accuracy of the students' metacognitive judgements.

The study consisted of four phases: 1) an initial test (pretest); 2) a programme for developing metacognitive skills (only in the experimental group); 3) a final test (post-test); and 4) a follow-up test (see Table **1**). A control group was established in which the intervention was not performed, and the results of the experimental and control groups were compared. The programme was implemented in one academic year during which initial contact was established with the centre and the teacher involved was trained. The programme lasted seven months.

Table 1. Sequence of the Intervention Design

Group	**Assignment Sample**	**Log Stream**			
		Pretest	**Programme**	**Post-Test**	**Follow-Up Test**
EG	NA	O_1	X	O_2	O_3
CG	NA	O_1	-----	O_2	O_3

Note. EG: Experimental Group; CG: Control Group; NA: non-random and unknown assignment.

The programme activities were based on a problem-solving process in which metacognitive strategies were applied to develop metacognitive skills and metacognitive knowledge. These activities were led as follows: a) An informative talk on the programme, its exercises and metacognitive components (session 1); b) A short description of metacognitive skills and metacognitive judgements, respectively. An academic task was conducted to develop metacognitive strategies before, during and after the students' performance based on the accuracy of their judgements (sessions 2 and 3); c) An academic task to apply metacognitive skills in a problem-solving process: 1) Understand the usefulness of metacognitive skills to improve the problem-solving process; 2) Develop metacognitive knowledge from the student's verbalisations (session 4); d) A task to improve planning metacognitive skills based on the problem-solving process and the verbalisations emitted on metacognitive skill development (session 5); e) An academic task to explain the role of metacognition in the problem-solving process (session 6); f) An academic task to develop self-regulation strategies in academic task performance (session 7 and 8); g) An academic task to apply metacognitive strategies through the problem-solving process (consolidation of acquired skills) (session 9).

5. RESULTS

To analyse the development of metacognitive skills between the assessment stages and both test groups, ANOVA was used to compare the mean difference scores for each group and the change score method was used to test differences between the post-test and the pretest, between the follow-up test and the post-test and between the follow-up test and the pretest.

The results of the analysis of intragroup and intergroup differences for metacognitive skill development are shown in Table **2**, specifically, the intragroup and the intergroup mean change due to metacognitive skill development over all stages of assessment, the standard deviation and the probability of type I error and its significance. To analyse the effect of the intervention, the treatment variable was used. The results from the mean difference between the post-test and pretest (Treatment 1), the mean difference between the follow-up test and the post-test (Treatment 2) and the mean difference between the follow-up test and the pretest (Treatment 3) are shown. The confidence level was set to 95%.

According to the results shown in Table **2**, the development of metacognitive skills in the experimental group was positive in all the assessment stages, with significant differences occurring in two out of the three (post-test/pretest and follow-up test/pretest). The experimental group scores increased significantly ($p < .05$) in Treatment 1 condition (*MD* = 2.1; *SD* = 1.6) and in Treatment 3 condition (*MD* = 5.3; *SD* = 1.7) and increased non-significantly ($p > .05$) in Treatment 2 condition (*MD* = 12.4; *SD* = 1.7). The development of metacognitive skills in the control group was lower than that in the experimental group in the three assessment stages, leading to higher significant development ($p < .05$) in Treatment 1 condition (*MD* = 5.3; *SD* = 1.7) and Treatment 3 condition (*MD* = 8.0; *SD* = 1.6) and non-significant development ($p > .05$) in Treatment 2 condition (*MD* = -1.4; *SD* = 1.5). Table **2** shows the mean change differences observed between the two test groups and indicates that metacognitive skill development in the experimental group was higher than in the control group in all the assessment stages (Treatment 1, Treatment 2 and Treatment 3). Statistical significance between both groups was not found in any of these assessment conditions (Treatment 1 *MD* = 1.1; *SD* = 2.5; Treatment 2 *MD* = 3.5; *SD* = 2.2; Treatment 3 *MD* = 4.5; *SD* = 2.3). However, these differences are

Table 2. Intragroup and Intergroup *Metacognitive Skill Development* Differences

Condition	Group	Intragroup Differences E-C		*p*	Intergroup Differences		*p*
		MD	*SD*		*MD*	*SD*	
Treatment 1 (Post-test/Pretest)	C	5.3	1.7	< .05*	1.1	2.5	0.662
	E	2.1	1.6	< .05*			
Treatment 2 (Follow-up test/Post-test)	C	-1.4	1.5	> .05	3.5	2.2	0.122
	E	12.4	1.7	> .05			
Treatment 3 (Follow-up test/Pretest)	C	8.0	1.6	< .05*	4.5	2.3	0.062
	E	5.3	1.7	< .05*			

Note. E: Experimental; C: Control; *** $p < .001$; ** $p < .01$; * $p < .05$.

close to statistical significance in Treatment 3 condition (follow-up test/pretest) (p = .062 > .05).

Based on these results, the generalisability theory (GT) [27] was applied to prove the validity of the design and the structure of the study and thereby generalise the study results. GT considered other sources of variation in assessing the internal validity of the study, as well as individual differences and intervention, since the number of exercises showed the greatest component of variability in this study. The software used for data analysis was EduG 6.0 [28]. The application of GT showed that if the number of exercises in the programme increased to at least 40, a statistically significant difference between both study groups' scores would be reached because the generalisability coefficient is nearly one when the precision of the generalisation level is appropriate (see Table **3**).

6. DISCUSSION

The intervention applied to develop metacognitive skills among a group of students aged 13–14 years revealed a significant effect of the intervention on the experimental group and a nearly significant effect between the two test groups (experimental and control). According to the intervention results, intra-group differences in metacognitive skill development between the post-test and the pretest and between the follow-up test and the pretest were statistically significant (p < .05). With respect to intergroup differences, metacognitive skill development in the experimental group was greater than in the control group between all assessment stages, and a positive tendency towards significance between the follow-up test and the pretest was observed (p = .062). In addition, the results are consistent internally because the experimental group exhibited a higher score than the control group in almost all assessment stages.

Furthermore, these differences were greater in the follow-up test in relation to those in the pretest and the post-test assessment stages; thus, they showed a positive increasing trend between the study groups based on the intervention programme effect and over time, although it cannot be assumed that these differences are due to the intervention programme. GT was applied to verify the effectiveness of the programme and determine whether an increase in the number of exercises yielded significant differences between the two groups' scores. The GT results indicate that, in further interventions, increasing the number of programme exercises to a minimum of 40 would be appropriate to reach significant results. Furthermore, these results suggest the positive reliability and validity of the programme and prove that this intervention is a step in the right direction. Therefore, if this programme is applied across the curriculum and at different times of the academic year, a better metacognitive skill development and learning of these curriculum subjects would occur.

Metacognitive skills were worked on and taught specifically with an intervention programme in the experimental group and not in the control one. Therefore, metacognitive skills development was lower in the control group than in the experimental group. Results show that there is more metacognitive development if it is developed specifically and deliberately, which is this study's working assumption. Research shows that metacognitive skills can be taught to students to improve their learning [2, 22, 29]. Students need explicit instruction in both cognitive and metacognitive strategies; they need to know they can choose which strategy to use in the context in question, and they need to monitor their use of these strategies and the success this can result in [30]. If metacognitive learning skills are developed, learning and academic task performance both improve. In addition, for further

Table 3. GT Results

Facets & G Coefficient	Option 1		Option 2		Option 3		Option 4		Option 5	
	N	Univ.	N.	Univ.	N	Univ.	N	Univ.	N.	Univ.
Participants	21	INF	21	INF	21	INF	21	INF	21	INF
Exercises	**6**	INF	**10**	INF	**20**	INF	**30**	INF	**40**	INF
Gender	2	2	2	2	2	2	2	2	2	2
G Coefficient	252		420		840		1260		1680	
	0.58		**0.69**		**0.82**		**0.87**		**0.90**	

interventions, adding other aspects to this study has been suggested to assess the results of the students' learning and their real academic task performance as dependent variables.

Despite these questions, the study results are consistent with those reported in the literature. There are some precedents reported in several studies that have implemented specific programmes at different educational levels that demonstrate the possibility and the benefits of the development of metacognition in education [23, 31-36]. Furthermore, the importance of obtaining more realistic self-judgements of performance by improving the calibration accuracy of students' judgements is suggested to develop metacognition, as others authors have indicated [36, 21, 37-39]. There is also recent literature on the role of self-regulation that might add another dimension to this study [18, 19, 30].

Finally, the underlying pedagogical implications of this study suggest the importance of the development of metacognitive skills in school curriculums by adjusting their objectives and methodologies. To achieve this aim, it is suggested that resources should be provided to teacher training to encourage the teachers' learning, understanding and development.

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