


Validation of a Pedagogical Innovation Strategy for the Strengthening of Metacognitive Skills

Validación de una estrategia de innovación pedagógica para fortalecer competencias metacognitivas

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Abstract

Different researchers have designed strategies for strengthening metacognitive skills, generally for specific areas of knowledge. The goal of this research was to validate a pedagogical innovation strategy to strengthen metacognitive skills in university students and determine their perception of the same. Three competencies were appointed: self-recognition, self-planning, and self-management of knowledge. The strategy considered three moments: I recognize myself; analysis of the students' metacognitive skills, I strengthen myself; study strategy planning and I project myself; monitoring and adjustment. A quantitative methodology was used with a pre-experimental design with pre-test and post-test with three different groups. Seventy-five students from 3 universities in Colombia were involved, one public university and two private who were taking part in three different courses, one virtual and two in distance mode within the framework of the health emergency generated by COVID-19. The competencies were assessed through the Schraw & Dennison (1994) Metacognitive Awareness Inventory (MAI) as a pre-test and post-test and were analyzed through a related-sample T-test. The perception was determined by a survey. It was evidenced that students strengthened the three metacognitive skills after the strategy implementation, the significance tests show this to be true. More than 95% of students pointed out that the strategy was effective and that favored the understanding of their learning processes, the organization of their study methods and the constant self-evaluation on the strengthening of their skills. It is suggested that the strategy is used in new learning environments to continue evaluating its effectiveness.

Resumen

Diferentes investigadores han diseñado estrategias para el fortalecimiento de habilidades metacognitivas, generalmente para áreas específicas del conocimiento. El objetivo de esta investigación fue validar una estrategia de innovación pedagógica para fortalecer competencias metacognitivas en estudiantes universitarios y determinar su percepción sobre la misma. Se establecieron tres competencias: autorreconocimiento, autoplanificación y autogestión del conocimiento. La estrategia contempló tres momentos: me reconozco; análisis de las competencias metacognitivas de los estudiantes, me fortalezco; planificación de estrategias de estudio, y me proyecto; seguimiento y ajustes. Se utilizó una metodología cuantitativa con un diseño pre-experimental con preprueba y posprueba con tres grupos diferentes; participaron 75 estudiantes de tres universidades en Colombia, una pública y dos privadas, quienes hacían parte de tres cursos diferentes, uno virtual y dos en modalidad remota en el marco de la emergencia sanitaria generada por la COVID-19. Las competencias se evaluaron a través del Metacognitive Awareness Inventory (MAI) a manera de pre-test y post-test y

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fueron analizadas mediante una prueba T de muestras relacionadas. La percepción se determinó a través de una encuesta. Se evidenció que los estudiantes fortalecieron las tres competencias metacognitivas después de la implementación de la estrategia, las pruebas de significancia así lo demuestran. Más del 95% de los estudiantes señalaron que la estrategia fue efectiva y favoreció la comprensión de sus procesos de aprendizaje, la organización de su plan de estudio y la autoevaluación constante sobre el fortalecimiento de sus competencias. Se sugiere que la estrategia sea utilizada en nuevos entornos de aprendizaje para continuar evaluando su efectividad.

Keywords / Palabras clave

Educational innovations, skills, evaluation, activity learning, university students, virtual environment, COVID-19 pandemic, confinement

Innovación educativa, competencia, evaluación, aprendizaje activo, estudiantes universitarios, entorno virtual, pandemia COVID-19, confinamiento

1. Introduction

Over time, numerous authors have delved into the study of metacognition. Early investigations, such as those by Tulving (1969), initially centered on understanding the mechanics of memory. The term metacognition was coined by Flavell (1976), who defined it as individuals' knowledge about their cognitive processes and the control they exercise over them. Costa (1984) associated metacognition with the capacity to understand what one knows, devise strategies for processing information, maintain awareness during problem-solving, and reflect on intellectual functioning. Haller et al. (1988) emphasized metacognition as individuals' awareness of their cognitive resources and their ability to regulate and monitor them. Ríos (1990) posited that metacognition involves knowledge of cognitive strategies for optimal problem-solving, highlighting the theme of self-regulation. These definitions collectively describe metacognition as the control and self-regulation of one's knowledge.

Metacognition plays a crucial role in enhancing critical thinking, aiding problem-solving, and fostering awareness of learning processes among students (Brooke & Debra, 2022). Simultaneously, metacognition serves as a reflective process wherein individuals strive to be conscious of their performance across various life activities, self-regulating to avoid or identify mistakes, and aiming for higher quality in their endeavors (Hijarro-Vercher et al., 2023; Tobón y López, 2009). This multifaceted concept encompasses cognitive processes (knowing how to know), affective motivational aspects (knowing how to be), and procedural elements (knowing how to do). As a result, metacognition is perceived as a process involving both knowledge and the regulation of action. More recently, Craig et al., (2020) identified four areas of metacognition: metacognitive knowledge, metacognitive experience, goals, and actions.

Numerous studies have been conducted in Higher Education Institutions to encourage metacognitive experiences among students. These studies focus on real-world applications of strategies for monitoring, controlling, and assessing cognitive processes during comprehension and text construction tasks, essential for learning and professional practice (Aripin & Rahmat, 2021; Bono et al., 2018; Campo et al., 2016; Maturano et al., 2002; Meneses et al., 2007; Roldán & Zabaleta, 2017). Some investigations aim to familiarize students with study strategies constituting metacognitive knowledge, requiring awareness of the person, the task, and the strategy involved (Ceniceros & Gutiérrez, 2009; Solórzano-Restrepo & López-Vargas, 2019; Vuorre & Metcalfe, 2021). Others also involve technological tools that allow a comprehensive training and promote critical and divergent thinking for problem solving in order to develop and enhance the professional skills required by students of today's era (Chou et al., 2023; Zarestky et al. 2022). Moreover, the education systems' motivation involves promoting metacognitive skills to enhance academic performance (Alegría & Rivera, 2021; Barandica, 2023; Barria et al., 2022; Moreno et al., 2022).

For example, in the realm of metacognitive knowledge, Ceniceros & Gutiérrez (2009) explored students' awareness of activities or problems, self-knowledge, appropriate thinking strategies, understanding when to employ them, and how to relate crucial information to existing knowledge. Their findings highlight the significance of self-regulation and task control, assessing the need for action planning, recognizing overlooked aspects, employing precise thought processes, and exerting effort to understand before solving.

Virtanen et al., (2014) proposed strategies in Finnish universities to heighten students' awareness of their learning processes, involving self-assessments, homework, feedback, learning logs, and tutorials. Their study concluded that activities incorporating motivational and affective components, coupled with learning strategies, significantly raise students' awareness of their learning, contributing substantially to academic performance.

Salgado et al., (2020) analyzed how the use of newspapers in a Mexican university triggers metacognition processes, fostering skills in content analysis, critical and creative thinking, and self-awareness of learning achievements and areas for improvement.

Roa (2016) implemented a teaching strategy focusing on individual goals and achievements, establishing a close relationship between goal setting, metacognitive processes, and skill qualification. Campo et al., (2016) research indicated a positive correlation between students' performance levels and metacognitive knowledge, affirming that metacognitive knowledge is essential for controlling what is produced, while self-regulation strategies contribute to planning, execution, and task evaluation. This aligns with Vuorre and Metcalfe (2021) assertion that an individual's recognition of their knowledge and limitations facilitates seeking help, enhancing learning in the metacognitive process.

Arias et al., (2014) determined in a study across three universities that students with established goals and achievement motivation exhibit better performance and greater academic success, irrespective of their learning style. Solórzano-Restrepo & López-Vargas (2019) analyzed the effects of metacognitive scaffolding and cognitive style, concluding that scaffolding significantly enhances planning, monitoring, self-evaluation, and metacognitive control.

On the other hand, Jaramillo & Simbaña (2014) report that students use as metacognitive strategies, the interview or questionnaire, educational portfolios, summaries, readings, and virtual tools that allow greater access to information and its dissemination, promote collaborative work, highlighting the importance of the use of blogs, wikis, chat, virtual classes, multimedia, and digital whiteboards, which are effective methods for the teaching-learning process. It is concluded that metacognitive strategies develop thinking skills such as memorizing, applying, analyzing, understanding, and creating meaningful learning that leads to problem solving and making correct decisions. The above coincides with the studies carried out by Desoete (2008), Schellings et al., (2013), Van Hout-Wolters (2009), Veenman (2013), who demonstrated with the use of various tasks and strategies a strong relationship between the components of metacognition and knowledge of the strategy, which includes understanding and how it can be used.

These results are consistent with findings presented in other studies, where strengthening metacognitive skills increases self-efficacy and academic commitments, which is reflected in improvements in academic performance (Loureiro, and Gomes, 2023; Taghani & Razavi, 2022; Zhao et al., 2024). However, research such that Karaoglan (2022) and Gamboa et al. (2023) also notes that at all levels of education, students face a variety of challenges related to learning. While it is recognized that multiple factors can influence learning at any given time, evidence suggests that one of these crucial factors is a lack of knowledge about how to learn, comprehension problems, lack of motivation and strategies. In other words, many students do not employ the appropriate strategies to achieve effective learning.

The previous path shows the importance of continuing to promote the development of metacognitive skills in university students, although there is progress, low metacognitive levels are still evident. This research focused on the creation and validation of a pedagogical innovation strategy, based on the principle of autonomy that promotes human development and personal self-realization.

2. Method

Specifically, this study set out to answer the research questions:

- What is the effect of implementing the Pedagogical Innovation Strategy on the development of self-recognition, self-planning, and self-management of knowledge skills in university students?
- What is the perception of students about the Metacognitive Pedagogical Innovation Strategy?

A quantitative methodology was used with a pre-experimental design with pre-test and post-test (Hernández-Sampieri & Mendoza, 2018) in three different groups. To answer the first question, an instrument was applied to each group at the beginning of the semester, the strategy was implemented, and the instrument was applied again; and to answer the second, a survey was applied to all participants at the end of the intervention. The independent variable was the innovation strategy, and the dependent variable was the metacognitive skills framed in the three established competencies. These aspects are detailed below.

2.1. Participants

The strategy was implemented in three Higher Education Institutions in Colombia, one public institution and two private institutions, named A, B and C. It had the participation of 75 students who had previously requested informed consent according to the Law 1581 of 2012 of data protection in Colombia. The Table 1 describes the participants.

Table 1.
Participants

Institution	No. Men	No. Women	Total
Institution A – group A	1	19	20
Institution B - group B	6	31	37
Institution C - group C	1	17	18
Total	8	67	75

The participants in this study were selected through purposive sampling. The strategy was implemented in the group with the highest number of students at each participating university, supervised by one of the researchers during the second semester of 2020. The decision was influenced by the availability and accessibility of the groups, and it was taken into account that the sample size in this type of research does not condition that it can be carried out, as pointed out by Chou & Feng (2019). These courses were part of different programs and academic levels, with two being delivered remotely and one virtually through Hybrid Learning Environments. The delivery modes included synchronous and asynchronous spaces through MEET and TEAMS platforms, as well as Moodle virtual classrooms.

2.2. Instruments

To validate the effectiveness of the pedagogical innovation strategy in the development of metacognitive skills, the Metacognitive Awareness Inventory - MAI, created by Schraw & Denninson (1994) and validated for use in Colombia for Huertas et al., (2014). This instrument has been used in different studies in Latin America such as Julio (2021), Largo & Hurtado (2024) and De la Portilla-Maya et al., (2022).

This instrument is made up of 52 items, distributed in two categories: cognition awareness and cognition regulation, and eight subcategories. These subcategories were associated with the three established competencies and the MAI was applied before and after the implementation of the strategy. The MAI is a self-report questionnaire, and its response options are on a Likert scale that is associated with a quantitative scale as follows: 1. completely disagree, 2. disagree, 3. neither disagree nor agree, 4. agree, and 5. completely agree.

To find out the participants' perception of the strategy, a survey was designed to find out whether they considered that the strategy had helped them to improve their metacognitive skills and whether they would use it again. This instrument was validated through expert judgment.

2.3. Procedure

The pedagogical innovation strategy created and validated in this study is based on the principle of autonomy, seeks to promote human development and personal self-realization, and is aimed at strengthening three metacognitive competencies. The design was based on the perspective of the socio-formative approach in which the competences are understood as integral actions in the face of activities and problems of the context, with suitability and ethical commitment and they are described, also from this point of view, considering the components: verb + conceptual object + purpose + reference condition (García et al., 2009; López, et al., 2021). Thus, the metacognitive skills of self-recognition, self-planning and self-management of knowledge that were proposed are:

- Self-recognition: identifies study strategies for the development of their metacognition, showing interest in their learning in an autonomous manner.
- Self-planning: proposes an action plan for the development of metacognition and the construction of new knowledge, considering activities and resources that have worked and incorporating new ones with a critical and creative attitude.

- Knowledge self-management executes the necessary resources for the development of their metacognition and to achieve learning goals, self-motivating and overcoming obstacles with responsibility.

To measure these competencies, in accordance with the conceptualization described above, a correspondence was established with the subcategories of the MAI so that each one includes aspects of cognition knowledge and cognition regulation as described in Table 2.

Table 2.
Metacognitive competences and correlation with MAI

Competence	Subcategory MAI	MAI items
Self-recognition	Declarative knowledge (DK)	5, 10, 12, 16, 17, 20, 32, 46
	Evaluation (RE)	7, 19, 24, 19, 36, 38, 50
Self-planning	Procedural knowledge (PK)	3, 14, 27, 33
	Planning (RP)	4, 6, 8, 22, 23 42, 45
Self-management of knowledge.	Conditional knowledge (CK)	15, 18, 26, 29, 35
	Organization (RO)	9, 13, 30, 31, 37, 39, 41, 43, 47, 48
	Monitoring (RM)	1, 2, 11, 21, 28, 34, 49
	Debugging (RD)	25, 40, 44, 51, 52

Source: Own elaboration based on MAI

Considering that Azevedo (2020), points out that metacognitive instruction must meet the following three conditions:

1. Embedding metacognitive instruction in the content matter to ensure connectivity,
2. Informing learners about the usefulness of metacognitive activities to make them exert the initial extra effort, and
3. Prolonging training to guarantee the smooth and maintained application of metacognitive activity (p. 94)

Based on the definition of the three competencies, the strategy was structured in three moments. In the first, called I know myself, the participants answer the MAI (pre-test), and using a worksheet, they analyze their three metacognitive competencies, and identify strengths and improvement areas; this was carried out during the first week. In the second moment, I strengthen myself, the participants, based on the analysis of the results and with the guidance of the teachers, plan and execute strategies aimed at strengthening their competencies, establish frequency of follow-up, evaluation, and assessment of effectiveness. This was done through a resource called the metacognitive log, through which the participants were asked to monitor the implementation of their strategies following the moments analyze, plan, execute, evaluate, reinforce, and modify, since metacognition is a reflective process, and these moments allow the student to know their thinking processes.

This second moment is the central part of the strategy and was carried out for approximately 14 weeks. During this time, teachers motivate students to execute the strategies, and through self-evaluation rubrics, they formally follow up on the implementation and its effectiveness every four weeks. Finally, in the third moment, I project myself, the MAI is applied again (post-test), students compare with their initial results, reflect on learning achieved and aspects to continue strengthening. It is recommended that from this, students identify changes and actions needed to start a new cycle of the metacognitive process.

In each course of each of the three universities, the corresponding programmatic content was developed, and the strategy was included through the three moments described. The MAI was applied at the beginning and end of the semester, and the perception survey at the end of the semester.

2.4. Data analysis

To determine whether the use of the strategy influenced the development of metacognitive competencies, a T-test for related samples was performed for each group using SPSS (Statistical Package for the Social Sciences, version 20). The independent variable was the strategy used and the dependent variable corresponded to the development of the three metacognitive competencies that were evaluated through the MAI as described in Table 2. In the statistical analysis, significant differences were considered to exist if $p < 0.05$.

3. Results

Tables 3, 4, and 5 present the T-test for related samples for each of the three competencies according to the MAI, for each of the three institutions A, B and C.

Table 3.
T-test for samples samples related University A

		Related differences					T	gl	Sig. (bilateral) p-value
		μ (pre-post)	Standard deviation	Standard error of the average	95% Confidence interval for the difference				
					Lower	Upper			
Self-recognition	DK pre								
	DK post	-0.375	0.496	0.117	-0.622	-0.128	-3.206	17	0.005
	RE pre								
	RE post	-0.618	0.792	0.192	-1.025	-0.21	-3.214	16	0.005
Self-planning	PK pre								
	PK post	-0.583	0.549	0.129	-0.857	-0.31	-4.507	17	0.000
	RP pre								
	RP post	-0.444	0.363	0.086	-0.625	-0.264	-5.194	17	0.000
Knowledge self-management	CK pre								
	CK post	-0.262	0.515	0.121	-0.518	-0.006	-2.157	17	0.046
	RO pre								
	RO post	-0.4	0.445	0.105	-0.621	-0.179	-3.817	17	0.001
	RM pre								
	RM post	-0.525	0.415	0.098	-0.732	-0.319	-5.373	17	0.000
	RD pre								
	RD post	-0.335	0.606	0.143	-0.637	-0.034	-2.346	17	0.031

In this institution it is observed that the students presented better skills after implementation in two of the three competencies. In Self-planning the significance tests show that there were significant differences in the two subcategories of the MAI (in PK $t = -4.507$ and $p = 0.00$; in RP $t = -4.507$ and $p = 0.00$). In the knowledge self-management competency there were also significant differences in the four subcategories of the MAI that comprise it (in CK, $t = -2.157$ and $p = 0.046$; in RO, $t = -3.817$ and $p = 0.001$; in RM, $t = -5.373$ and $p = 0.000$; in RD, $t = -2.346$ and $p = 0.031$).

Table 4
T-test for samples samples related University B

		Related differences					T	gl	Sig. (bilateral) p-value
		μ (pre-post)	Standard deviation	Standard error of the average	95% Confidence interval for the difference				
					Lower	Lower			
Self-recognition	DK pre	-0.625	0.561	0.092	-0.812	-0.438	-6.782	36	0.000
	DK post								
	RE pre	-0.743	0.804	0.132	-1.011	-0.475	-5.625	36	0.000
Self-planning	RE post								
	PK pre	-0.73	0.647	0.106	-0.945	-0.514	-6.866	36	0.000
	PK post								
Knowledge self-management	RP pre	-0.691	0.583	0.096	-0.885	-0.497	-7.214	36	0.000
	RP post								
	CK pre	-0.562	0.62	0.102	-0.769	-0.356	-5.518	36	0.000
	CK post								
	RO pre	-0.562	0.551	0.091	-0.746	-0.378	-6.201	36	0.000
	RO post								
	RM pre	-0.637	0.57	0.094	-0.827	-0.447	-6.798	36	0.000
	RM post								
	RD pre	-0.346	0.471	0.077	-0.503	-0.189	-4.472	36	0.000
	RD post								

In this group there were significant differences in the three competencies defined and evaluated through the MAI. In the eight subcategories established, $p=0.000<0.05$

Table 5
T-test for samples samples related University C

		Related differences					T	gl	Sig. (bilateral) p-value
		μ (pre-post)	Standard deviation	Standard error of the average	95% Confidence interval for the difference				
					Lower	Lower			
Self-recognition	DK pre	-0.285	0.426	0.1	-0.497	-0.073	-2.834	17	0.011
	DK post								
	RE pre	-0.574	0.597	0.141	-0.871	-0.277	-4.077	17	0.001
Self-planning	RE post								
	PK pre	-0.5	0.575	0.136	-0.786	-0.214	-3.688	17	0.002
	PK post								
Knowledge self-management	RP pre	-0.397	0.494	0.116	-0.642	-0.151	-3.41	17	0.003
	RP post								
	CK pre	-0.378	0.757	0.179	-0.754	-0.001	-2.116	17	0.049
	CK post								
	RO pre	-0.4	0.51	0.12	-0.654	-0.146	-3.328	17	0.004
	RO post								

RM pre	-0.333	0.525	0.124	-0.595	-0.072	-2.691	17	0.015
RM post								
RD pre	-0.144	0.531	0.125	-0.408	0.119	-1.155	17	0.264
RD post								

There were significant differences in all three competencies, $p < 0.05$, except in the subcategory RD.

It is observed that the students of the three universities strengthened the three metacognitive competencies after the implementation of the strategy, as shown by the significance tests. Figure 1 shows that the students' averages in the three defined competencies were higher after the implementation of the strategy, which corroborates that the differences are in favor of the post-implementation results.

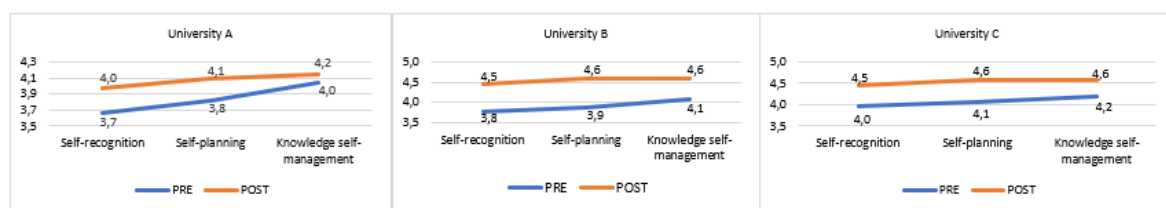


Figure 1. Average scores in the three competencies before and after the implementation of the Pedagogical innovation strategy

In self-recognition, students in institution A went from an average of 3.7 to 4.0; in institution B from 3.8 to 4.5; and in institution C, from 4.0 to 4.5. This competency groups the metacognition subcomponents of declarative knowledge and evaluation, and it was shown that the differences in favor of the intervention were statistically significant in each institution. In the self-planning competency, statistically significant differences were also observed after the use of the pedagogical innovation strategy, the averages went from 3.8 to 4.5; from 3.9 to 4.6 and from 4.1 to 4.6 in institutions A, B and C respectively. This competency groups the MAI subcomponents of procedural knowledge and planning and in each the T-test showed that the differences were significant in favor of the use of the strategy. In the third competency, self-management of knowledge, which groups the MAI subcategories of conditional knowledge, organization, monitoring, and evaluation, there were also statistically significant differences in favor of the use of the strategy, in this competency the averages went from 4.0 to 4.5 in institution A, from 4.1 to 4.6 in institution B, and from 4.2 to 4.6 in institution C.

Regarding the students' perception, 97% considered that the strategy was effective. When asked to argue their response, they indicated that the strategy helped them to adequately organize study time, draw up a study plan, set learning goals, use different study strategies such as summaries, mind maps, concept maps, organize their previous knowledge and articulate it with what they learned, identify weaknesses and strengths, apply strategies in other subjects, which allowed them to obtain successful results, evidenced in their final course grades.

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Additionally, 99% stated that they would continue to use metacognitive strategies in their daily lives. This result shows that the strategies employed probably had a positive impact on the students' learning and, therefore, allowed them to improve their academic performance. The participants expressed having strengthened their skills, which is consistent with the results of the Mai applied at the beginning of the semester and the results obtained at the end of the course. Among the strategies used, the following stand out: preparation of glossaries, key words, summaries, use of the calendar, organization of assignments by due date, concept maps, reviewing content, making diagrams and constant self-evaluation. It can be stated that the students had a very good perception of the strategy implemented.

4. Discussion

The objective of this study was to validate the Pedagogical innovation strategy for the development of metacognitive competencies in university students. Specifically, it focused on strengthening three competencies: self-recognition, self-planning and self-management of knowledge, defined in the framework of this research. The results show that there were significant differences in the development of these competencies in the participants of the three universities after the implementation of the strategy. These results are similar to those of other studies that have shown that the use of different strategies and activities generates a strong relationship of the components of metacognition and strategy knowledge which favors the learning process which is reflected in academic performance (Desoete, 2008; Satrústegui et al., 2024; Schellings et al., 2013; Van Hout-Wolters, 2009; Veenman, 2013; Virtanen et al., 2014).

The first moment of the strategy, I recognize myself, allowed students to do a self-assessment exercise of their metacognitive skills using the MAI while reflecting on their learning goals in each of the courses they were enrolled in. This moment is framed in the proposal of different researchers regarding the importance of students recognizing what they know and what they do not know, to know when to seek help and thus favor learning about the metacognitive process and face new situations (Dennis & Somerville, 2023; Vuorre & Metcalfe, 2021). This stage also favors the development of metacognitive judgment, an aspect recommended by different researchers (Montoya et al., 2021).

In the second moment, I strengthen myself, the students proposed strategies that would allow them to improve their metacognitive competencies. Although the teachers made some general suggestions about possible strategies, each student had to propose his or her own, the frequency of follow-up and, in a permanent monitoring exercise, determine whether or not they were working for him or her. Other studies with university students aimed at increasing students' metacognitive awareness have used strategies such as self-assessments, homework, feedback, student learning journals, tutorials, and digital narratives, demonstrating that they can be an efficient strategy for the development of metacognitive skills (Virtanen et al., 2014; Lavrysh et al., 2023)

This type of strategies was identified in what the participants proposed, and it was possible to verify, as Virtanen et al., (2014) point out, the positive of combining activities and learning strategies to increase the students' awareness of their process. This aspect responds to the recommendations of other studies such as Mora-Rosales et al., (2023), who state that students can use strategies to plan their time, prioritize activities, and monitor and evaluate their own learning performance. The metacognitive register, used for this second moment, allowed students a process of permanent reflection on their learning.

Also in this second stage, the use of rubrics was included for students to self-evaluate what was planned, its execution and follow-up to improve the metacognitive competencies of self-recognition, self-planning, and self-management of knowledge. This allowed, by students to increase their commitment and responsibility in the selection of strategies, and teachers to promote self-evaluation and reflection in the learning process (McMillán & Hearn, 2008; Zimmerman, 2000; Panadero & Alonso-Tapia, 2013). On the other hand, the use of self-assessment rubrics allowed students to monitor their own activity, reducing subjectivity as suggested by García-Sanz (2014) and Krebs (2022).

Finally, the third moment of the Pedagogical innovation strategy project allowed students, using the MAI, to analyze and compare the development of their metacognitive competencies before and after having implemented the strategy in order to make new changes aimed at advancing their level of performance. Also at this time, using the worksheet, students reflected on the level of achievement reached against the expectations and learning challenges proposed at the beginning of the course. Incorporating different metacognitive strategies together with instruments to measure metacognition, contributes to achieve the improvement of learning processes through the metacognitive awareness that we seek to forge in students as suggested by Zapata-Zapata & Vesga-Bravo (2023a).

This study showed that these proposed moments and the resources used had positive effects on the development of the three metacognitive competencies, As shown in figure 1.

The validation of the Pedagogical innovation strategy in three courses of different academic programs, from different institutions, developed in virtual and remote modality, allows offering to the educational community a pedagogical strategy that favors the development of metacognitive competencies of self-recognition, self-planning, and self-management of knowledge in university students. This strategy can be implemented in all formative levels and fields of higher education for the development of students' metacognitive competencies in different learning situations since it is not limited to a specific field of knowledge (Greene et al., 2015; Kleitman & Narciss, 2019).

The articulation between the metacognitive competences of self-recognition, self-planning and self-management and the MAI, provide university students with a methodological proposal that is easy to understand and apply in their learning process, according to their tastes and needs, in a flexible and adaptive manner that in the perspective of the socio-formative approach contributes to comprehensive training, in relation to their ethical life project and suitable performance in different contexts, as it strengthens self-criticism, autonomy and responsibility.

The implementation of strategy allowed validating the resources created for its development (worksheet, metacognitive log and self-assessment rubrics) as well as the relevance of the adoption of the MAI and its articulation with the established competencies. From the point of view of the research teachers, the relevance of these resources was observed in the way students easily and adequately made use of each resource as appropriate in the three moments of the process "I recognize myself", "I strengthen myself" and "I project myself", for reflection on their metacognitive processes.

The results of the application of the MAI at the beginning and at the end of the process show a higher level of performance in the metacognitive competencies of self-recognition, self-planning, and self-management, after implementation. The students' perception of the effectiveness of the strategy (97%) and their interest in continuing to implement it autonomously (98%) confirm the pedagogical nature of the pedagogical innovation strategy.

5. Conclusions

The validation of the strategy allows us to present it to the university community, for its implementation by teachers and students in the academic spaces of their training or autonomously, with the certainty that it will contribute to the development of their metacognitive competencies of self-recognition, self-planning, and self-management. Although the study was carried out in three different universities, with students from various training programs, the total number of participants can be considered low, so it is desirable that other studies use the Pedagogical innovation strategy with a larger number of students and thus obtain new data on its effectiveness in the development of metacognitive competencies.

This research opens the way for new studies in the field of metacognition and learning in search of pedagogical and didactic strategies that enhance self-recognition and autonomy in learning, aimed at finding new ways of learning at different levels of education. New studies can use or adapted the Pedagogical innovation strategy for the development of competencies in elementary and middle school students. It is also desirable to analyze the effect of the strategy through correlation studies, for example with academic achievement, motivation, development of critical thinking, among others.

CRediT

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