

## Psychometric Analysis of the State Metacognitive Inventory in University Students from City of Arequipa, Peru

Análisis psicométrico del inventario de estrategias metacognitivas en estudiantes universitarios de la ciudad de Arequipa, Perú

Análise psicométrica do inventário de estratégias metacognitivas em estudantes universitários da cidade de Arequipa, Peru

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**Abstract:** In this psychometric research, the internal structure and reliability of the Metacognitive Strategies Inventory by O'Neil and Abedi (1996) were analyzed in a sample of university students from Peru. For this purpose, an intentional sample of 404 students from a private university in the city of Arequipa was taken, of which 54.5% were men with an average age of 19 years. The version of the test validated by Vallejos et al. was applied, (2012) which has a three-factor structure: Self-knowledge, Self-regulation and Evaluation. To calculate the validity of the instrument, confirmatory factor analysis was applied, and to calculate reliability, Cronbach's Alpha test and McDonald's Omega test were applied. The results corroborated the three-factor structure, but only the first dimension obtained adequate reliability indices.

**Keywords:** Cognition, self-control, self-learning, self-monitoring, psychology of education.

**Resumen:** Esta investigación psicométrica analizó la estructura interna y la confiabilidad del Inventario de Estrategias Metacognitivas de O'Neil y Abedi (1996) en una muestra de estudiantes universitarios de Perú. Para ello, se tomó una muestra intencional de 404 estudiantes de una universidad privada de la ciudad de Arequipa, de los cuales el 54,5% eran varones con una edad promedio de 19 años. Se aplicó la versión de la prueba validada por Vallejos et al. (2012), la cual tiene una estructura de tres factores: autoconciencia, autorregulación y evaluación. Para calcular la validez del instrumento se utilizó el análisis factorial confirmatorio, y para calcular la fiabilidad se emplearon la prueba alfa de Cronbach y la prueba omega de McDonald. Los

resultados confirmaron la estructura trifactorial, pero sólo la primera dimensión obtuvo índices de fiabilidad adecuados.

*Palabras claves:* Cognición, autocontrol, autoaprendizaje, autocontrol, psicología educativa.

**Resumo:** Esta pesquisa psicométrica analisou a estrutura interna e a confiabilidade do Inventário de Estratégias Metacognitivas de O'Neil e Abedi (1996) em uma amostra de estudantes universitários do Peru. Para isso, foi retirada uma amostra intencional de 404 estudantes de uma universidade privada da cidade de Arequipa, dos quais 54,5% eram homens com idade média de 19 anos. Foi aplicada a versão do teste validada por Vallejos et al. (2012), que possui uma estrutura de três fatores: autoconsciência, autorregulação e avaliação. A análise fatorial confirmatória foi utilizada para calcular a validade do instrumento e para calcular a confiabilidade, foram utilizados o teste alfa de Cronbach e o teste ômega de McDonald. Os resultados confirmaram a estrutura trifactorial, mas apenas a primeira dimensão obteve índices de confiabilidade adequados.

*Palavras-chave:* Cognição, autocontrole, autoaprendizagem, autocontrole, psicologia educacional.

## INTRODUCTION

Metacognition is defined as the set of cognitive and motivational processes that facilitate conscious and strategic self-regulation of learning, although it is traditionally referred to as “knowledge about cognition,” as it was initially conceptualized by John Flavell in the 1970s. (Flavell, 1979). However, metacognition has been approached from different theoretical approaches and theoretical frames. The constructivist theory of Jean Piaget (1896-1980), for example, emphasized the active nature of learning that occurs as a product of the child's interaction with his environment (Piaget, 1983); while Lev Vygotsky (1896-1934) pointed out that cognition is regulated through language as a product of learning mediated by culture (Vygotsky, 1995). In both cases, self-regulation of learning is mentioned as an internal cognitive process, but for Piaget the level of mental development determines learning, and for Vygotsky mediated learning leads to cognitive development (Martí, 1995; Rodríguez, 1998).

On the other hand, the theory of mind (ToM) emerged at the rise of cognitive psychology, and is dedicated to knowing the mental states of other people from the inference of their behavior, but based on self-knowledge (Skidelsky, 2011). To this end, the false belief test, as well as the Baron-Cohen test for evaluating emotional expressions, have allowed us to test various hypotheses that validate the idea that at a certain age, human beings, and even some animal species, acquire the ability to understand and predict the behavior of others (Vales et al., 2016). For example, it is around five years of age that children use more executive strategies in solving ToM tasks, which depends on their level of self-awareness and their degree of neurocognitive development (Sáiz et al., 2010), which is based on mirror neurons and the functioning of the prefrontal cortex (Santana, 2010).

Precisely, the theory of executive functions has served to biologically base self-awareness and behavioral self-regulation thanks to the development of this brain area, which regulates verbal fluency, attentional control, cognitive flexibility, planning and inhibition (Urrego et al., 2016). In this way, executive control would allow the use of metacognitive strategies to solve complex problems and guide behavior towards goals, with multiple educational implications both in learning and in peaceful coexistence in the school context, since it has been shown that students with deficient executive functions are more involved in acts of bullying as aggressors (Rivera, 2018).

Likewise, self-regulated learning includes cognitive, affective, motivational, volitional and metacognitive aspects involved in achieving goals in various personal and interpersonal contexts (Greene, 2018); which has a strong predictive power in the academic performance of students (Assis et al., 2022; Valle et al., 2008) and is manifested through certain intellectual styles (Bernardo et al., 2008) and learning styles (Arias et al., 2014; Oliveira & Zedu, 2022) that determine their preferred learning modes. Hence, metacognition and self-regulated learning are directly linked, since Flavell (1979) himself pointed out that metacognition implies knowledge of one's own cognitive processes and the regulation of them.

However, although initially it was recognized that self-knowledge and self-regulation of learning were the two components that defined metacognition, later the evaluation or monitoring of learning was added as a third characteristic component of metacognition (Tobias & Everson, 2009; Wolters & Pintrich, 2002). Thus, knowledge of one's own cognitive abilities includes various elements such as metamemory (Nelson & Narens, 1990), cognitive interests (Schúkina, 1972), self-awareness (Jiménez, 1999), various executive functions (Santana, 2010), and even self-concept (Herrera et al., 2007), since how students perceive themselves and their intellectual abilities are determinants of their academic performance (Villarroel, 2001).

For example, in Peru, a recent study with schoolchildren between 10 and 14 years old established that implicit beliefs about their intelligence are associated with their academic performance in the areas of communication and mathematics, and with the support they receive at home (Melo & Salcedo, 2021). In Colombia, another study with a sample of 392 students from first to fifth grade in basic secondary education from an educational institution in Barranquilla and another in Bogotá, reported that no significant differences were found between men and women in verbal fluency, cognitive flexibility and planning; but depending on the place of origin in favor of Bogota residents (Urrego et al., 2016). This highlights the need to consider the gender and sociocultural context of students when assessing metacognitive competencies, leaving prejudices aside (Lundeberg & Mohan, 2009).

Regarding self-regulated learning, Zimmerman introduced the construct in 1989, and it is defined as the degree to which a student has an active role in the process of his or her own learning (Zimmerman & Moylan, 2009). So, students who self-regulate their learning know how to plan, control and direct their mental processes towards achieving goals; and they include various rehearsal, elaboration and organization strategies, which are maintained by underlying affective and motivational processes (Peñalosa et al., 2006). In fact, it is from approximately six years that children are able to self-regulate their emotions, but even from three months of age, emotional self-regulation emerges under the influence of the alert network and at nine months, control of attention is evident through language (Ato et al., 2004). Positive Psychology, for example, has provided findings that positive emotions promote creativity and practical problem solving (Fredrickson, 2001, Waugh & Fredrickson, 2006).

Likewise, it has also been observed that self-efficacy serves as a bridge between metacognitive awareness and self-regulated learning (Montoya et al., 2021), since self-efficacy refers to the beliefs that people have about their own abilities (Bandura & Locke, 2003; Zimmerman & Moylan, 2009). So self-efficacy is associated with the self-regulation of students' learning and academic performance (Alegre, 2014). Thus, self-regulated learning includes cognitive, emotional, temperamental, behavioral and interpersonal aspects; that allow the activation and inhibition of behavior based on certain purposes (Nachon et al., 2020). Finally, evaluation or monitoring involves a reflective phase that assesses the effectiveness of self-regulatory strategies applied in the teaching-learning process (Torrano & González, 2004), which involve the use of knowledge heuristics, selection strategies, mechanisms control, etc. (Serra & Metcalfe, 2009). In summary, metacognitive skills encompass self-awareness to plan, monitor, and evaluate learning; which are equivalent to goal-oriented thinking, but involve personal, situational and social factors. Therefore, teachers must provide experiences to students that allow them to put these skills into practice (Efklides, 2009; Everson & Tobias, 2002; Hartman, 2002a; Schraw, 2002).

The implementation of metacognitive processes in the education of basic instructional skills (Gourgey, 2002) has proven to be an efficient resource for teaching reading comprehension (Aragón & Caicedo, 2009; McKeown & Beck, 2009; Williams & Atkins, 2009), written composition (Fidalgo & García, 2009; Harris et al., 2009), the elaboration of speeches (Ellis & Zimmerman, 2002), the solution of mathematical problems (Gurat & Medula, 2016; Mayer, 2002; Hsu et al., 2016; Wolters & Pintrich, 2002), in virtual learning contexts (Azevedo & Witherspoon, 2009), with children who have intellectual disabilities (Desoete, 2009) and in the training of teachers to improve their teaching strategies (Duffy et al., 2009; Hartman, 2002b).

In this sense, teachers can promote the use of their students' cognitive skills through the creation of cognitive scaffolds (Sánchez-Domínguez et al., 2021), the application of metacognitive strategies to self-regulate learning activities (Brunning et al., 2007), the design of tasks that allow them to experiment with metacognitive strategies (Efklides, 2006), the implementation of intervention workshops (Gutiérrez et al., 2022) and the promotion of a motivating learning climate that favors academic commitment (Cuadra-Martínez et al., 2022; Matos, 2009); although contextual and social factors that can negatively influence the establishment of educational goals should not be left aside (Arias et al., 2022).

All of this raises the need to evaluate metacognitive skills using duly validated methods and instruments (Schraw, 2009; Schraw & Sperling, 1994). In fact, there are several instruments that evaluate metacognitive strategies such as the *Metacognitive Awareness Inventory*, the *Learning and Study Strategies Inventory*, the *Motivated Strategies for Learning Questionnaire*, the *Components of Self-regulated Learning*, the *Self-Regulated Learning Interview Schedule*, the *Rating Student Self-regulated Learning Outcomes Teacher Scale*, the *Metacognitive Skills Scale*, the *Metacognition in Multiple Contexts Inventory*, the *Awareness of Independent Learning Inventory*, the *Metacognition Self-Assessment Scale*, and many other tests that are applied in educational contexts (Craig et al., 2020; Peñalosa et al., 2006; Torrano & González, 2004).

One of the most used tests is the *State Metacognitive Inventory* by O'Neil and Abedi (1996), which is based on the multidimensional conception of metacognition that includes awareness strategies, cognitive strategies, planning and self-assessment. This test was designed with four subscales and 20 items that were originally applied to 219 university students, corroborating its four-factor internal structure through exploratory factor analysis and reliability through Cronbach's alpha test, with adequate indices that exceed .7 in all the subscales (O'Neil & Abedi, 1996).

A psychometric study carried out in Chile with this instrument involved its application to 642 students between 12 and 14 years old from 12 educational institutions in Santiago, and corroborated its multidimensional structure with adequate reliability indices that exceed .8 using Cronbach's alpha test. (Forster & Rojas-Barahona, 2010). In Peru Vallejos et al. (2012) applied it to 687 university students, reporting that the *Inventory of Metacognitive Strategies* (IMS from now on), presents an internal structure of three factors: self-knowledge, self-regulation and evaluation, which explained 46% of the total variance of the instrument. For this purpose, exploratory factor analysis was applied with the method of extraction of principal components and Oblimin rotation. Likewise, the 20 items obtained high item-test correlation coefficients, which accounts for the homogeneity of the items that comprise it. The reliability of the test was also calculated using the internal consistency method with Cronbach's alpha test with indices that are within a range of .7 and .9, which means that the test presents evidence of validity and reliability, although its four-factor structure was not corroborated.

In Colombia, the psychometric properties of the IMS were analyzed in a sample of 220 4th and 5th grade children from an educational institution located on the north coast of that country. It was reported that the inventory had a three-factor internal structure with adequate goodness-of-fit indices, but the internal consistency indices were only adequate for the Self-Knowledge dimension, while the Self-Regulation and Evaluation dimensions were low, below .6 (Arias et al., 2022). Thus, the objective of the present study is to analyze the construct validity and reliability of the IMS in a sample of university students Psychology program at a private university in Arequipa.

This validation is important, because it is necessary to evaluate the metacognitive strategies of higher level students, considering that other research in Peru has reported that university students do not have adequate study habits (Montes, 2012), they have low levels of self-efficacy (Arias & Rivera, 2018a; Dominguez-Lara & Fernández-Arata, 2019), they do not self-regulate their learning (Alegre, 2014; Arias et al., 2020) and they tend to postpone their academic duties (Alegre, 2013; Arias & Rivera, 2018b; which is possibly explained because their motivation for academic achievement is low (Arias et al., 2018), their learning styles tend to be passive rather than reflective (Arias, 2011; Arias et al., 2014) and the

management of their emotions is not oriented towards the application of their metacognitive skills in academic activities (Arias et al., 2016). Likewise, another factor that could explain this phenomenon may be mediated by the role played by university professors in Peru, who lack an academic profile (Arias, 2013), do not read updated information or consult scientific journals (Arias, 2021), do not have relevant academic production because their motivation to research is low (Arias et al., 2022) and they do not use metacognitive strategies (Arias & Linares, 2018).

Consequently, the general objective of this study is to analyze the psychometric properties of the IMS in a sample of university students from the city of Arequipa. The first specific objective involves verifying the internal structure of the instrument through confirmatory factor analysis, and the second specific objective involves estimating the reliability of the instrument through the internal consistency method.

## MATERIALS AND METHODS

The study developed is of an instrumental type with the purpose of analyzing the construct validity and reliability of the IMS (Ato et al., 2013).

A total of 404 students from a private university in the city of Arequipa, located in southern Peru, were evaluated, of which 54.5% were men and 45.5% women. The participants' ages ranged from 16 to 36 years with an average of 18.6 years. Likewise, 22.5% in the first semester, 74.6% of those evaluated were in the second semester, 1.6% in the third and 1.3% in the fourth semester.

The O'Neil and Abedi (1996) *Inventory of Metacognitive Strategies* was used, which consists of 20 items and five response alternatives on a Likert scale ranging from "Never" (1), "Rarely" (2), "Regular" (3), "Many times" (4) and "Always" (5). The version validated by Vallejos et al. (2012) in Peru was applied, that has three subscales in which the items are distributed as follows: Self-knowledge includes items 1, 4, 5, 6, 9, 10, 11, 12, 13, 14, 18 and 19; Self-regulation includes items 15, 16, 17 and 20; and Evaluation includes items 2, 3, 7 and 8; which presents reliability indices higher than .7, and a percentile rating scale with five levels: Very low, low, medium, high and very high, for each of the three subscales and the global score. The test can be applied individually and collectively with a duration of approximately 20 minutes. The sample was selected by non-probabilistic methods using the quota sampling technique.

The students were evaluated within their class schedule, after having permission from the head of the university's Psychology Department. The application of the test was carried out collectively, since the students signed the informed consent. The data was collected in the month of October 2023. After collecting the data, statistical processing was carried out according to the objectives of the study.

The descriptive analysis was carried out through measures of central tendency and dispersion. Regarding the factorial structure of the test, it was evaluated through a confirmatory factor analysis. Considering the size of the sample and the fact that all the items had a normal distribution, robust maximum likelihood was used as an estimator. For the reliability analysis, Cronbach's alpha and McDonald's omega coefficients were used (Ventura-León & Caycho-Rodríguez, 2017). The JASP program version 0.19 was used to process the data.

## DISCUSION OF RESULTS

In Table 1 it can be observed that all of the items in the *Inventory of Metacognitive Strategies* present a normal distribution, given that their skewness and kurtosis values are in the interval [-1.5; 1.5]. Likewise, there is a certain ceiling effect in items 6 "You make sure you understand what needs to be done, and how to do it" and 11 "You check your work while you are doing it", given that their average scores exceed four points.

**Table 1**

*Univariate descriptives of the Inventory of Metacognitive Strategies*

	Media	SD	Skewness	Kurtosis
Item 1	3.899	0.776	-0.206	-0.524
Item 2	3.359	0.864	-0.045	-0.103
Item 3	3.666	0.827	-0.235	-0.186
Item 4	3.879	0.808	-0.542	0.158
Item 5	3.748	0.922	-0.320	-0.375
Item 6	4.057	0.803	-0.364	-0.565
Item 7	3.399	0.936	-0.141	-0.340
Item 8	3.537	0.903	-0.030	0.958
Item 9	3.785	0.897	-0.496	-0.049
Item 10	3.933	0.826	-0.511	0.082
Item 11	4.007	0.884	-0.729	0.230
Item 12	3.847	0.846	-0.419	-0.238
Item 13	3.636	0.888	-0.310	-0.113
Item 14	3.829	0.826	-0.362	-0.222
Item 15	3.651	0.836	-0.293	-0.060
Item 16	3.795	0.891	-0.516	0.011
Item 17	3.733	0.796	-0.167	-0.430
Item 18	3.931	0.871	-0.408	-0.589
Item 19	3.616	0.799	-0.223	-0.219
Item 20	3.978	0.832	-0.400	-0.528

When analyzing the factorial structure of the test, it was found that the three-factor model proposed by Vallejo et al. (2012) is confirmed. Most of the goodness-of-fit indices consider said factorial model to be valid:  $\chi^2/gf= 2.166$ ; CFI= .909; and RMSEA= .054 and SRMR= .0481; while the TLI= .897 was a little lower than the minimum expected value of .90.

**Table 2**  
*Factor loadings of the Inventory of Metacognitive Strategies*

Factor	Items	Factorial charge	Standar error	p	$\alpha$	$\omega$
Self-knowledge	Item 1	.420	.039	< .001	.839	.840
	Item 4	.523	.039	< .001		
	Item 5	.546	.044	< .001		
	Item 6	.573	.033	< .001		
	Item 9	.559	.045	< .001		
	Item 10	.651	.038	< .001		
	Item 11	.494	.045	< .001		
	Item 12	.581	.038	< .001		
	Item 13	.549	.041	< .001		
	Item 14	.568	.041	< .001		
Self-regulation	Item 15	.572	.039	< .001	.671	.672
	Item 16	.535	.046	< .001		
	Item 17	.619	.037	< .001		
	Item 20	.594	.038	< .001		
Evaluation	Item 2	.549	.045	< .001	.657	.666
	Item 3	.447	.044	< .001		
	Item 7	.603	.049	< .001		
	Item 8	.683	.043	< .001		
$\chi^2/df$		361.801/167= 2.166				
CFI	.909					
TLI	.897					
RMSEA	.054					
SRMR	.048					

Additionally, it was found that the Self-knowledge factor has adequate reliability ( $\alpha = .839$ ;  $\omega = .840$ ); while the factors of Self-regulation ( $\alpha = .671$ ;  $\omega = .672$ ) and Evaluation ( $\alpha = .657$ ;  $\omega = .666$ ) obtained values close to the minimum required ( $\geq .70$ ), so they are partially reliable and should be interpreted carefully.

## CONCLUSIONS

The objective of the present study was to analyze the psychometric properties of the *Inventory of Metacognitive Strategies* in a sample of Psychology major students from a private university in the city of Arequipa. This instrument was originally created by O'Neil and Abedi (1996), but was validated in a sample of university students from the north of the country by Vallejos et al. (2012), however, considering the condition of multiethnicity and multiculturalism experienced in Peru, it is necessary to carry out psychometric studies in the different regions of the country.

The results revealed that after confirmatory factor analysis, the test has an internal structure of three factors, as reported by Vallejos et al. (2012). That is, the 20 items of the IMS are distributed in the dimensions of Self-knowledge, Self-regulation and Evaluation. However, although the test presents evidence of construct validity, given its internal structure of three factors, the resulting reliability indices for each of them were adequate for the Self-knowledge dimension, which obtained an Alpha coefficient of .839 and an Omega coefficient of .840; while in the Self-regulation and Evaluation dimensions only acceptable coefficients were obtained, with values between .657 and .672.

These results are similar to those reported by Arias et al. (2022), in a sample of primary level students from Colombia, in which only the Self-knowledge dimension obtained adequate reliability indices, while the Self-regulation and Evaluation dimensions obtained low coefficients, even lower than .6, despite the fact that the internal structure of three-factor was also confirmed by confirmatory factor analysis. Although in that study only McDonald's Omega test was used to estimate reliability, while here both Cronbach's Alpha and McDonald's Omega tests have been used. A possible explanation for these results could be the size and age of the sample, since on that occasion 220 children were evaluated, while on this occasion, 404 university students were evaluated.

This would mean that first, as the sample size increases, reliability indices tend to be higher. Secondly, it could also be that older students better understand the test items, or are able to discern their own metacognitive abilities. In this sense, it has been pointed out that younger students lack metacognitive skills, since they are in the process of development and their prefrontal structures are not mature enough (Martí, 1995; Sáiz et al., 2010; Vales et al., 2016). On the other hand, the finding that only the Self-knowledge dimension was adequately reliable in the study by Arias et al. (2022), suggests that young children do have sufficient knowledge of their own cognitive abilities and interests, but they do not have adequate strategies for self-regulation of learning and evaluation, because possibly, they have not been trained in it (Brunning et al., 2007).

This explanation could also be applied to the present sample of university students, if we consider, as previously explained, that the various studies indicate that Peruvian university students lack study habits (Montes, 2012), they have low levels of self-efficacy (Arias & Rivera, 2018a; Dominguez-Lara & Fernández-Arata, 2019), they do not self-regulate their learning (Alegre, 2014; Arias et al., 2020), their learning styles are passive (Arias, 2011; Arias et al., 2014) and present high or moderate levels of academic procrastination (Alegre, 2013; Arias & Rivera, 2018b; Dominguez-Lara, 2017).

On the other hand, it should be noted that self-knowledge is a key aspect that guides cognitive skills around students' interests and prior knowledge, facilitating the connection between past and new knowledge, and linking self-efficacy with specific goals. (Bandura & Locke, 2003; Everson & Tobias, 2002; Skidelsky, 2011; Tobias & Everson, 2009). Therefore, self-knowledge could be a basic support point for the development of self-regulation of learning and its corresponding self-assessment.

Likewise, subsequent studies should continue to deepen the analysis of the psychometric properties of the IMS in Peru, evaluating more representative samples not only from Arequipa, but from other regions of the country; and also assessing aspects such as convergent and divergent validity, factorial



invariance, etc. Furthermore, although the test has turned out to be valid and acceptably reliable, it must be considered that the O'Neil and Abedi scale is one of the most widely used instruments in the international educational field (Craig et al., 2020); but there are other tests with better psychometric properties such as the *Metacognitive Awareness Inventory* (MAI), which has recently been standardized in 13 Latin American countries (Gutierrez et al., 2024).

To conclude, it only remains to say that the present study has among its limitations the size and non-probabilistic selection of the sample, but it constitutes a relevant precedent in the Peruvian and Latin American educational field, since there are few studies that have applied the IMS, or that have accounted for its psychometric properties. Therefore, although its internal structure of three-factor has been corroborated, and adequate reliability has been obtained for the Self-Knowledge factor and acceptable for the Self-Regulation and Evaluation factors, it is suggested to use the IMS in the Peruvian educational context, with some caution, applying as I support other tests that also evaluate meta-cognitive skills or related constructs, such as self-regulated learning, academic self-efficacy, academic achievement motivation, learning styles, among others.

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