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Measurement of Metacognition: Adaptation of Metacognitive State Inventory in Spanish to Mexican University Students

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Abstract: Some of the most important skills of university students is to develop the capacity to resolve problems posed by their communities, which implies that students become independent, autonomous and self-regulated. Also they need to be capable of monitor, asses and modify their learning through their own process of metacognition, this way they can develop the required knowledge and improve their learning. To analyze it, the objective of this research is to evaluate the psychometric properties of the Metacognitive State Inventory in Mexican university students. For this reason, the Metacognitive State Inventory was applied to 908 students. To confirm a second order hierarchy model with four first order factors, confirmatory factor analysis was used (CFA).Four items were eliminated to obtain a better model fit. Internal consistency was accessed through McDonald's omega coefficient. In this way, evidence of the construct validity and reliability of the instrument was provided. The Inventory of the Metacognitive State was correlated with the CEVEAPEU Questionnaire, obtaining significant positive correlations between both instruments, thus providing certainty of convergent validity.

Keywords: *Metacognition, self-regulation, metacognitive state inventory, inventory.*

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Introduction

Over decades, several educational institutions mainly took care of the accumulation of knowledge in all educational levels, which carried to the repetition of contents without a logical meaning by the students (Khan, 2012). Forgetting, the school, its principal function in society: the solution of real problems of the group to which it belongs. But, today, in the XXI century, appears the necessity, in the superior level, that students to be educated with the capacity of solving the wide range of problems proposed by their communities. This requires that the students not only learn an specific content, but also, that they learn to learn, which implies that they become independent, autonomous and self-regulated, producing a continuous, reflexive and strategically learning (Hernandez Rojas & Diaz Barriga, 2013; Monereo & Pozo, 2001). These essential characteristics in students are conceptualized in the construct “metacognition”.

Elosua and Garcia (1993) perform an interesting theoretical revision of metacognition and indicate that it refers to the person's thought processes related to their own cognitive system (content, processes, capacities, limitations) and to the regulatory effects that this knowledge may have on its activity (Weinert & Kluve, 1987). According to Flavell (1981, 1985), this metacognitive knowledge comprises three important variables:

- Personal variables or knowledge of its own cognitive capacities and limitations of learning.
- Variables of task or knowledge of the characteristics and difficulties of any particular task, which allows the planning and effective distribution of resources.
- Variables of strategy or knowledge of advantages and disadvantages of the procedures in the accomplishment of tasks, that is to say, is the knowledge that facilitates the planning and supervision of the cognitive strategies to be used.

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For Weinert and Kluwe (1987), in metacognition, more than the knowledge about the self-knowledge, its essential the control of this. Concerning, Elosua and Garcia (1993) found appropriate to differentiate two significant components of the metacognition:

- Knowledge of knowing: which includes the knowledge of what, how, when and where.
- Knowledge control: which includes the planning and application of knowledge, supervision and evaluation.

The knowledge of what, how, when and where it's intimately related with the personal variables, of tasks and strategy (Elosua & Garcia, 1993). However, the control of the knowledge involves planning, supervision and evaluation. Planning its related with the design of the action plan for an specific job and implies the identification of the purpose (or objective) of learning, as well as the selection of strategies and activities required in front of the petition of the tasks and adequate distribution of time and resources. Supervision implies the use of metacognitive strategies that try to prove if the activity is made according to the planned, recognizing and correcting the mistakes or reprograming the strategies and activities when it is necessary. And finally, the evaluation includes the evaluation of the capacities and own resources the, the petitions and purposes of the task, the processes and the reached results, also the introduction of the modifications and rectifications that are considered necessary for new executions of the task.

Therefore, the valid and trustable analysis of the metacognitive state is vital for university education because it provides an indicator of the degree to which students are aware of their self-regulation processes; which implies the recognition and use of different learning strategies (Colthorpe, Shariirad, Ainscough & Zimbardi, 2018); thus developing the competence of learning that will guarantee the application of the content learned in class to different contexts. O´Neil and Abedi (1996) define metacognition as the conscious and periodic self-checking of the achievement of the objectives and, when necessary, the selection and application of different strategies. For O'Neil and Abedi (1996) one is aware of the process in the following ways:

- Planning: It must have a learning goal, which can be assigned by someone external or by the learner itself, and from this it is precise to make a plan to achieve it.
- Self-checking: once the plan is executed, it is necessary a self-checking mechanism to monitor the achievement of the goal.
- Cognitive strategy: It must have several strategies to monitor the intellectual activity and in this way, make the necessary adjustments. The cognitive strategy can be independent or dependent of the discipline or field to which the task belongs.
- Awareness: The individual is 100% aware of the process.

Frequently authors mention, in literature, that metacognition is related with other process that develops according students foment their own abilities and strategies in their learning process: self-regulation. The concepts "self-regulation" and "metacognition" constantly are used as synonyms (Dinsmore, Alexander & Loughlin, 2008). However, Whitebread and Pino Pasternak (2010) affirm that is rising a consensus in the research literature that indicate: "metacognition refers specifically to the supervision and control of the cognition, while self-regulation refers to the monitor and control of all the aspects of human function, including emotional, social and motivational aspects." (p. 693).

Studies show the metacognitive process as part self-regulation and affirm it has a positive effect significant in the student efficiency (Rosario et. al, 2014). In general, students can describe themselves as self-regulated in function of the level in which they are metacognitive, motivational and behaviorally active in their own process of learning (Zimmerman, 1986, 1989). Rosario, Lourenco, Paiva, Valle and Tuero-Herrero (2012) indicate that self-regulation is related with an active process in which people establish the objectives that guide their learning, as well as, monitor, regulate and control their cognition, motivation and behavior to reach them. Kayacan and Sonmez Ektem (2019) mention that "the self-regulation of a behavior requires the active control of resources such as students time, working environment and peer cooperation" (p.313) This means that, individuals with high self-regulation skills take an active role in their own learning process (Ozen Uyar, Yilmaz Genc & Yasar, 2018). As can be seen, metacognition is an important component o self-regulation and studies like this may benefit the understanding of both concepts.

In the same manner, the valid measure of metacognition is crucial for the theoretical development and empirical of the construct. Multiple studies exist to measure "autoregulation", but few investigations study "metacognition". Some investigations measure the construct in some thematic content, like in the case of Favieri (2013) who designed an instrument to examine the metacognition though the resolution of integrals. As well, Jaramillo and Osseas (2012) designed a scale called Metacognition Instrument, which contributes evidence about its excellent content validity, but the facts that it shows about the construct validity are insufficient. On the other hand, the Metacognitive Awareness Inventory (MAI) from Harrison and Vallin (2017) counts with items relevant to the construct, with evidence of construct validity but it is dichotomous. It is also worth noting that the authors of this study have detected in multiple investigations the questionable validity of scales that only provide two options of answer. An instrument widely publicized and with adequate content validity, used for the same end in the English language was formulated by O'Neil

and Abedi (1996). By which can be ca amend the past deficiencies, so with the purpose of collaborating with the psychometry, it was aimed: evaluate the properties of the Metacognitive State Inventory in a sample of Mexican university students.

Methodology

Research Goal

This instrumental study had a non-experimental cross-sectional design. This study is defined as an instrumental study (Montero & Leon, 2005) and, with the goal of collaborating with the metacognition´s evaluation, the objective of this is: To evaluate the properties of the Metacognitive State Inventory in a sample of Mexican university students.

Participants

The sample was composed of 908 university students (65% were female and 35% were male), enrolled from the first to tenth semester at a public Mexican university. The participants' mean age was 20.30 years (*SD* = 3.45), 95% *CI* (20.11, 20.66), and ranged from 17 to 55 years. No significant and important differences were found between the mean age of men and women ($t_{(862)} = 1.892$, $p > .05$).

The distribution by faculty being the following: 11% belonged to the Faculty of Public Accounting and Administration; 9% to the Faculty of Law and Criminology; 12.8% to the Faculty of Nursing; 12.6% to the Faculty of Psychology; 37.6% to the Faculty of Nutrition; 11.1% to the Faculty of Biological Science, and 6% to the Faculty of Social Work.

Measurements

Metacognitive State Inventory (O´Neil & Abedi, 1996). This is a self-report scale composed of 20 items. The items are rated along a four-point, Likert-type scale (from 1 = “a lot” to 4 = “nothing”). The scale is composed by four dimensions: Awareness, Cognitive Strategy, Planning, and Self-Checking.

Subscale of Metacognitive Strategies of CEVEAPEU Questionnaire (Gargallo, Suarez-Rodriguez & Perez, 2009). This is a scale with Likert items with a distance of 5 to 1, measuring 4 learning strategies (subscales): Knowledge of Objectives and Evaluation Criteria, Planning, Self-Assessment and Control and Self-Regulation.

Procedure

1) Content validity

The instrument was presented to two researchers expert in metacognition and self-regulation, who advised the inclusion, in parenthesis, the words *questions for the test* and *exam* at the end of the items, because metacognition include metacognitive strategies that could be undertaken before a learning activity (such as that suggested by the original instrument) or an exam.

2) Cultural adjustment

A cultural adjustment and the verification of its comprehensibility were undertaken by applying the instrument to 60 students with similar characteristics to the above described sample, with the pertinent adjustments carried out based on the responses.

3) Application

Before applying the instrument to the study’s total sample, training was given to the interviewers. For the application of the instrument, consent was requested to the faculty directors, professors and students. At all times it was insisted that the information obtained would be treated with total discretion, ensuring the anonymity of the participants. The students answered the instrument in a self-administered way.

4) Data Analysis

Before performing confirmatory factor analysis, the Kaiser-Meyer-Olkin (*KMO*) test for sampling adequacy was assessed; a value >.60 is considered adequate. Likewise, it is necessary to reject the null hypothesis of equivalence of the correlation matrix to an identity matrix through the Bartlett's test of sphericity; small values (<.05) of the significance level indicate that factor analysis may be performed (Lloret-Segura et al., 2014).

The assumption of multivariate normality was assessed through Mardia's multivariate kurtosis coefficient; this assumption is fulfilled if its value is lower than 10. Due to the multivariate normal assumption was not fulfilled, the bias-corrected percentile bootstrap method was performed with 2000 bootstrap samples. This latter procedure is a non-parametric technique through which random samples were generated in order to estimate the standard errors and test the significance of the parameters of the model when this assumption is rejected (Kline, 2015).

To confirm a second order hierarchy model with four first order factors, confirmatory factor analysis was used (CFA). The discrepancy function was optimized by the maximum likelihood method (ML). The adjustment to the data was assessed by means of eight indices: relative chi-square (χ^2/df), goodness of fit index (GFI) and its adjusted formula (AGFI), standardized fit index (NFI), comparative fit index (CFI), standardized mean square error (SRMR) and mean square approximation error (RMSEA). Values of $\chi^2/df \leq 5$, *GFI*, *NFI*, *NNFI* y *CFI* ≥ .90, *AGFI* ≥ .85, *SRMR* ≤ .10 y *RMSEA* ≤ .08 indicate an acceptable fit to the data (Hu & Bentler, 1999).

Internal consistency was accessed through McDonald's omega coefficient (ω ≥.70), convergent validity through the average variance extracted (*AVE* ≥.50), construct reliability through the Hancock and Mueller coefficient (*H* ≥.70) (McDonalds, 1999; Fornell & Larcker, 1981; Hancock & Mueller, 2001).

The factor loadings for each one of the items should be equal to or greater than .40 (λ ≥.40) (Williams, Onsman, & Brown, 2010). Statistical analyses were performed through SPSS and AMOS 24.

Results

Descriptive Statistics of the Items Composing the Metacognitive State Inventory

Table 1 shows the descriptive statistics (mean, standard deviation, skewness, and kurtosis) of the Metacognitive State Inventory. Table 2 shows the inter-item correlations. Item two showed the highest mean score (*M* = 3.59, *SD* = .569) and item 15 the lowest (*M* = 3.09, *SD* = .818). None of the items composing the scale presented excessive skewness or kurtosis (≤ ± 1.5) (Kline, 2015). When values of asymmetry and kurtosis below 1.5 are found, it can be affirmed that the items that make up the scale are not redundant measures

The Kaiser-Meyer-Olkin (KMO) value was .934 and Bartlett's test of sphericity was significant (χ^2 = 5148.562, *df* = 190, *p* <.001), it was proceeded to perform directly CFA (Suhr, 2006).

Table 1. Descriptive statistics

Item	M	SD	Sk	K
1. Estaba consciente de mi propio pensamiento.	3.58	0.572	-1.017	0.244
2. Revise mi trabajo mientras lo estaba haciendo.	3.59	0.569	-1.087	0.605
3. Trate de descubrir las ideas principales de lo que se me solicitaba en la actividad (o preguntas de examen).	3.54	0.615	-1.157	0.996
4. Trate de entender los objetivos de la actividad (o preguntas de examen) antes de intentar resolverlas	3.55	0.633	-1.24	1.141
5. Estuve consiente de la forma de razonar sobre el contenido en cada parte del examen o tarea.	3.46	0.635	-0.862	0.207
6. Corregi mis errores	3.33	0.751	-0.874	0.114
7. Me pregunte a mi mismo(a) como los cuestionamientos de la actividad (examen) se relacionaban con lo que yo ya sabia.	3.29	0.775	-0.798	-0.104
8. Trate de determinar lo que la actividad (prueba) requeria.	3.41	0.669	-0.836	0.153
9. Estaba consciente de la necesidad de planificar mi curso de accion.	3.2	0.763	-0.624	-0.226
10. Casi siempre sabia que parte de la actividad (prueba) habia dejado por completar.	3.37	0.732	-0.926	0.202
11. Pense el significado de cada apartado de la actividad (pregunta) antes de empezar a responder.	3.37	0.717	-0.875	0.132
12. Me asegure de entender exactamente lo que tenia que hacer y como hacerlo.	3.53	0.616	-1.04	0.475
13. Estuve consciente de como se iba llevando a cabo mi proceso de pensamiento.	3.29	0.732	-0.698	-0.157
14. Yo supervise mi progreso en la actividad (prueba) y cuando fue necesario, cambie mis tecnicas o estrategias.	3.22	0.787	-0.712	-0.171
15. Utilice múltiples tecnicas o estrategias de pensamiento para resolver la actividad (preguntas de la prueba).	3.09	0.818	-0.482	-0.567
16. Decidi como resolver la actividad (preguntas de la prueba).	3.37	0.703	-0.856	0.225
17. Estuve consciente de mis intentos por entender las instrucciones de la actividad (examen) antes de intentar resolverlas.	3.45	0.682	-1.03	0.515
18. Revise mi precision a medida que progresaba en la actividad (prueba).	3.24	0.767	-0.756	0.03
19. Seleccione y organice la informacion relevante para resolver cuestiones de la actividad (preguntas de la prueba).	3.3	0.736	-0.748	-0.076
20. Trate de entender las indicaciones de cada apartado de la actividad (o preguntas de la prueba) antes de intentar resolverlas	3.48	0.653	-0.938	-0.018

Notes. M = mean, SD = standard deviation, Sk = Skewness, K = Kurtosis

Table 2. Inter-item correlations of the Metacognitive State Inventory

	I1	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**I10**	**I11**	**I12**	**I13**	**I14**	**I15**	**I16**	**I17**	**I18**	**I19**	**I20**
I1	1	.29	.26	.26	.36	.24	.19	.24	.26	.23	.27	.27	.30	.27	.20	.25	.29	.33	.24	.25
I2		1	.34	.30	.30	.27	.20	.26	.28	.25	.30	.29	.29	.27	.23	.29	.24	.33	.28	.27
I3			1	.43	.29	.16	.24	.34	.26	.24	.29	.31	.25	.22	.24	.28	.26	.25	.29	.33
I4				1	.42	.21	.24	.34	.27	.25	.24	.34	.27	.22	.23	.25	.32	.25	.27	.31
I5					1	.34	.28	.35	.33	.32	.33	.34	.37	.29	.31	.37	.29	.33	.31	.31
I6						1	.27	.27	.24	.25	.24	.24	.26	.26	.26	.23	.21	.30	.32	.25
I7							1	.44	.28	.24	.30	.28	.31	.20	.27	.30	.28	.27	.29	.26
I8								1	.40	.28	.34	.35	.34	.29	.26	.37	.33	.28	.30	.40
I9									1	.32	.33	.30	.42	.38	.29	.31	.31	.36	.35	.28
I10										1	.34	.30	.29	.22	.21	.30	.28	.30	.32	.28
I11											1	.46	.36	.27	.25	.37	.34	.34	.33	.40
I12												1	.44	.31	.24	.35	.39	.29	.32	.46
I13													1	.42	.37	.37	.36	.37	.30	.34
I14														1	.48	.36	.27	.34	.33	.27
I15															1	.45	.28	.38	.36	.29
I16																1	.44	.37	.34	.37
I17																	1	.41	.37	.44
I18																		1	.52	.40
I19																			1	.46
I20																				1

Notes. All the correlations have a significance level of p <.001.

Confirmatory Factor Analysis (CFA)

The value of the Mardia's coefficient was 119.08, which provides evidence for the non-fulfillment of multivariate normality assumption. Therefore, the bootstrap procedure was used for the interval estimates of the parameters.

A second order hierarchy model with four first order factors was determined, the 20 items were assigned with their respective factor. However, the data adjustment values were not acceptable, χ^2/df = 4.313, *GFI* = .923, *AGFI* = .901, *CFI* = .891, *NFI* = .864, *NNFI* = .874, *RMSEA* = .062 (90% CI, .057, .067), and *SRMR* = .044, so it was necessary to eliminate four items to achieve good values of goodness of fit. The final model (Figure 1) showed good goodness-of-fit indices, χ^2/df = 3.430, *GFI* = .953, *AGFI* = .937, *CFI* = .931, *NFI* = .906, *NNFI* = .917, *RMSEA* = .053 (90% CI, .047, .059), and *SRMR* = .037. The analysis of standardized factorial loadings (λ) for the model, have the expected direction and have the average recommended value. Likewise, the model showed internal evidence of convergent validity (*AVE* = .680). The 16 items composing Metacognitive State Inventory did not show high correlations (r >.70); thus, it is possible to say there is no multicollinearity. These data provide evidence of internal discriminant validity (Kline, 2015; Merino-Soto et al., 2017).

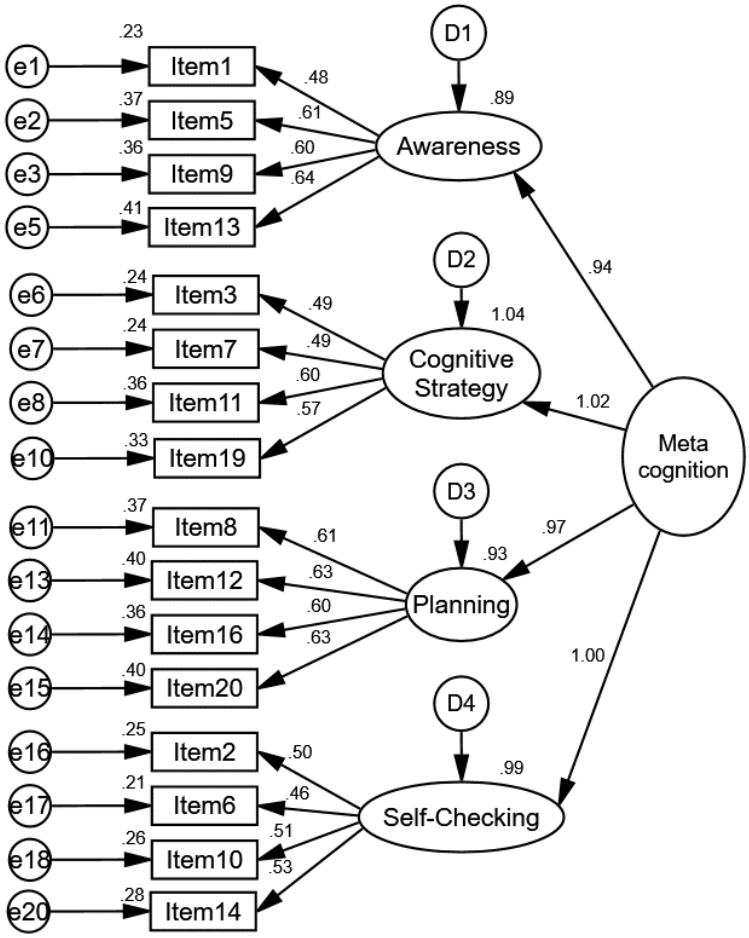

Figure 1. Model for the Metacognitive State Inventory

Internal Consistency of Metacognitive State Inventory

The Metacognitive State Inventory showed good internal consistency (ω = .880 and *H* = .880), the internal consistency of the factor Awareness was close to the recommended value (ω = .673 and *H* = .680), the internal consistency of the factor Cognitive Strategy was close to the recommended value (ω = .620 and *H* = .630), the factor Cognitive Strategy showed acceptable internal consistency (ω = .713 and *H* = .710), and finally the factor Self-Checking showed bad internal consistency (ω = .570 and *H* = .570). Therefore, the Metacognitive State Inventory can be considered as a reliable instrument at least in general.

Regarding the convergent validity, significant statistic correlations between the different groups from Metacognitive State Inventory and the strategies from the Subscale of Metacognitive Strategies of CEVEAPEU Questionnaire (Gargallo, Suarez-Rodriguez & Perez, 2009).

The strongest correlations are found in the relations between the different dimensions of Metacognitive State Inventory and the subscale Planning and Self-Assessment. As well as the total sum of both scales correlated in a significant positive way at the bilateral level (.01).

Table 3. Correlations between Metacognitive State Inventory and CEVEAPEU Questionnaire

	Subescale of Metacognitive CEVEAPEU Questionnaire	**Knowledge of Objectives and Evaluation Criteria**	**Planning**	**Self-Assessment**	**Control and Self-Regulation**
Metacognive State Inventory	.095**	.044	.123**	.071*	.033
Awareness	.102**	.035	.136**	.063	.047
Cognitive Strategy	.090**	.072*	.084*	.071*	.045
Planning	.065	.035	.090**	.056	.011
Self-Checking	.063	.006	.107**	.051	.008

**. The correlation is significant at the 0.01 level (bilateral).
*. The correlation is significant at the 0.05 level (bilateral).

Discussion and Conclusions

At first moment, the theoretical conceptualization is presented, which was taken as the base for the evaluation of content validity. Once applied the instrument, its validity and reliability were examined. In relation to the analysis of construct validity, the results, through factorial confirmatory analysis, confirmed the original factorial structure; but, CFA suggest the elimination of certain items. In relation to the indexes of internal consistency evidence of acceptable reliability in the majority of dimension was presented. Besides, the correlations that were observed between the Metacognitive State Inventory and the Subscale of Metacognitive Strategies of CEVEAPEU Questionnaire provide evidence about the convergent validity of the instrument.

Theoretically metacognition conceived by O'Neil and Abedi (1996) is closely related to the categorization of Elosua and Garcia (1993), who recognize two components of metacognition: knowledge of knowing and knowledge control. According to the authors, the four factors found by O'Neil and Abedi (1996), and of which its factor structure was verified, could be perfectly grouped into the theoretical categorization of Elosua and Garcia (1993), since knowledge of knowing is Awareness factor according to the process presented by O'Neil and Abedi (1996) and Planning, Self-Cheking and Cognitive Strategy represent the control of knowledge developed by Elosua and Garcia (1993).

For the use of the instrument in the Spanish language, it is suggested grouping the items for its interpretation according to figure 1, obtaining the means and comparing with the minimum and maximum values to obtain. It is accurate mentioning that what is presented here is a validation of the Metacognitive State Inventory and not a normalization, this being the main limitation of the study. Nevertheless, it is common to observe, in certain publications, the interpretations of the scales by creating intervals, which result from the difference of the maximum and minimum value with its subsequent division between desired intervals.

Finally, according to statistical analysis used to evaluate the psychometric properties of the instrument, it can be confirmed that the version translated and adapted to Spanish of the Inventory State Metacognitive is a valid and reliable measure to examine the metacognition in Mexican university students.

Suggestions

If the goal is to analyze in detail the metacognition, it is recommended for future investigations that the learning and evaluation activities' design consider the phases mentioned in this article. Through these means, an ideal measure of metacognition will be available, and more empirical evidence about the criterion validity.

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