

Adaptation and Validation of the Motivated Strategies for Learning Questionnaire—MSLQ—in Engineering Students in Colombia*

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With the aim of characterizing self-regulated learning of engineering students in a Colombian university, students were asked to answer a Spanish version of the Motivated Strategies for Learning Questionnaire (MSLQ); this questionnaire enables obtaining information on epistemic motivation and learning strategies of the students in the courses they are studying. The data found suggest the dimensional structure of the questionnaire did not meet the context of those students. It was decided to make a new translation of the MSLQ into Spanish and make linguistic and cultural adaptations in order to achieve a valid instrument; this work began with the International Test Commission (ITC) guidelines. As a result, a new questionnaire was attained, MSLQ-Colombia. The objective of this article is to present the method used to obtain the MSLQ-Colombia, and the study of the psychometric properties of the new questionnaire. The psychometric properties studied were the construct validity, content validity and reliability. These properties were determined by factor analysis, Cronbach's Alpha and experts consultation. The participants of this research were 1218 engineering students and 12 university teachers. The results indicate the new questionnaire is valid and reliable, provide information to those who may use MSLQ-Colombia to comprehend the results of their investigations, and offer the international community new empirical evidences on MSLQ psychometric properties. It led to the conclusion that the MSLQ-Colombia has similar psychometric properties to the original MSLQ in English, and that the new questionnaire can be useful for the Spanish speaking international community. This article can be a valuable guide for those researchers, who desire making translations-adaptations of the MSLQ into languages-cultures different from English or Spanish, and also, to translate-adapt questionnaires of self-report besides the MSLQ.

Keywords: MSLQ, self-regulated learning; learning strategies; motivation to learn; psychometric research; engineering education

1. Introduction

Motivation and learning strategies are elements attached to learning processes [1, 2]. Motivation, understood as epistemic curiosity, affects the willingness to learn [1]. A student intrinsically motivated to learn, who considers important, interesting and useful the task of learning will generate expectancies that will lead them to be highly involved in their study activities [3–5]. Also, a student who considers that their chances of success in the learning process depends on their own efforts and also feel capable of performing the task of learning, tend to adopt meaningful learning approaches in their learning processes [6].

The strategies are mental operations that a student can do to facilitate the completion of the task [7]. There are different types of strategies: cognitive [1], metacognitive [8] and resources management [9]. Cognitive strategies like select, organize and elaborate the information of the topics of study enable the student interpreting and understanding the topics [1]. In other words, the use of cognitive strategies

facilitates the construction of new knowledge from previous experience and new information processing. Metacognitive strategies include operations such as setting goals for what you want to learn, coordinating cognitive strategies, monitoring learning processes and adjusting strategies according to the contexts and learning outcomes [8]. Metacognition enables the students to control or self-regulate their learning processes [1, 10]. Resources management strategies refers to the administration of resources such as time to study, anti-distractors management, social interaction and peer support for learning, among others. Management of these resources stimulates the cognitive and meta-cognitive learning strategies performance [9].

Given the importance of motivation and strategies in learning process, research has been conducted in order to determine whether these two factors are well-regulated by the student. Without wanting to generalize or to ignore the specific context of these investigations, two common conclusions are: the student can learn to use learning strategies and can self-regulate their epistemic moti-

1 vation from their own initiatives or from processes
 2 activated by the classroom social context. Addition-
 3 ally, the motivation to learn and use of learning
 4 strategies have positive linear correlations with the
 5 undergraduate students' academic performance.
 6 Some suggested sources, among others, for more
 7 information about these topics are the works of
 8 Gutiérrez and Meneses [11], Richardson, Abraham
 9 and Bond [12], Diseth [13], Mega [14] and Cleary,
 10 Zimmerman and Keating [15].

11 The recognition that motivation and learning
 12 strategies affect the student's education processes
 13 implies to find ways to characterize these two
 14 variables. The characterization, understood as the
 15 determination of distinctive features of motivation
 16 and learning strategies of a specific population,
 17 provides information for both the teacher and the
 18 students [16]. It provides the teacher starting points
 19 to propose educational interventions that seek to
 20 motivate and increase the student's set of strategies
 21 [17, 18]; it also provides information to evaluate the
 22 motivational and cognitive effects of such interven-
 23 tions. It enables the students self-testing their moti-
 24 vation and study methods and gives them inputs to
 25 identify strengths and weaknesses of their study
 26 processes. This self-testing process will enable the
 27 student to adjust their idea of why to learn and how
 28 to study [17, 18].

29 Within the methods commonly used to character-
 30 ize the motivation and learning strategies are
 31 included: direct observation of the student behavior
 32 to deduce what mental mechanisms triggers when
 33 performing learning tasks [19], the personal inter-
 34 view to ask the student what they do or think when
 35 performing the learning tasks [20] and the oral
 36 report in which the student explains aloud what
 37 they do while studying [19]. Another method that
 38 has gained strength in recent years is the monitoring
 39 through computerized environments. This method
 40 consists in monitoring observable cognitive indica-
 41 tors with online tools when students perform their
 42 learning activities [21]. The main advantage of the
 43 methods aforementioned is that they provide
 44 detailed information; however, the main disadvan-
 45 tage is that its rapid conclusion is affected as study
 46 population increases.

47 A method that resolves the above-mentioned
 48 disadvantage is the self-report questionnaire. The
 49 self-report questionnaire is a set of statements about
 50 the motivation that the student may have or strate-
 51 gies that could be using to perform their study tasks.
 52 To fill in the questionnaire, the student reads each
 53 statement and then indicates whether or not it is true
 54 on them. Among the well-known questionnaires to
 55 measure the two variables of interest in this work are
 56 included: Learning and Study Strategies Inventory
 57 (LASSI) [18], Escalas de Estrategias de Aprendizaje

(ACRA) [9], CEA: Cuestionario de Estrategias de
 Aprendizaje [22] and the Motivated Strategies for
 Learning Questionnaire (MSLQ) [17].

The MSLQ stands out among those question-
 naire named as a tool widely used in different
 careers around the world [23]. The reason for its
 widespread use is that this questionnaire has pre-
 sented proper psychometric characteristics, even
 within student population in different educational
 contexts from which it was originally designed [23].
 The MSLQ was created by Pintrich and a group of
 cognitive psychologists in the late twentieth century,
 it was first used among students at the University of
 Michigan (USA) [17] and it was written in English.
 In the next section of this article is presented the
 structural model for the MSLQ items.

When a psychometric instrument like MSLQ is
 going to be used in a different language and social
 context from which it was originally designed, a
 process of adjustment of the instrument is required
 [24]. The adaptation consists in translating the
 instrument into the native language of the people
 who will use it and adapt the tool to the new cultural
 context. The aim of the process of adaptation is that
 the translated and adapted instrument has psycho-
 metric properties comparable to the original
 instrument [24]. Currently, the MSLQ has been
 translated, adapted and applied to students from
 countries such as Argentina [25], Australia [26],
 Brazil [27], China [28], Colombia [29], Egypt [30],
 Spain [31, 32], Iran [33], Mexico [34], South Africa
 [35], Turkey [36], United States [37], among others.
 In Colombia, Sabogal and his coworkers adapted
 and validated the MSLQ with a population of
 university students of the health care field [29].
 Such MSLQ adaptation consists on a questionnaire
 of 40 items, with proper reliability indexes, to
 characterize some of the MSLQ original constructs
 scales. Due to the MSLQ has 81 items, this short
 version of the questionnaire doesn't allow assessing
 some dimensions of the epistemic motivation con-
 struct, like: extrinsic goals, control of learning
 beliefs, expectancies of academic performance and
 expectancies for learning. Likewise, in the case of
 learning strategies, the items in the Sabogal short
 questionnaire don't include memorization, help
 seeking and peer learning. Thus, Sabogal MSLQ
 adaptation provides partial, not total, measures of
 the constructs of motivation and learning strategies
 considered in the MSLQ. On the other hand, the
 Colombian Society of Psychology confirmed, to the
 authors of this article that in their data base there
 wasn't any record of a psychometric instrument
 resulting from a process of adaptation and valida-
 tion of the MSLQ in Colombia.

It was decided to manage the instrument Cues-
 tionario de Estrategias de Aprendizaje y Motiva-

Table 1. Scales and subscales of the MSLQ [17]

Scale	Component	Sub-scales	Items
Motivational aspects	Value	1. Intrinsic goals	1, 16, 22, 24
		2. Extrinsic goals	7, 11, 13, 30
		3. Task value	4, 10, 17, 23, 26, 27
	Expectancy	4. Control of learning beliefs	2, 9, 18, 25
		5. Self-efficacy for learning and performance	5, 6, 12, 15, 20, 21, 29, 31
	Affect	6. Anxiety	3, 8, 14, 19, 28
Learning strategies	Cognitive	1. Rehearsal	39, 46, 59, 72
		2. Organization of ideas	32, 42, 49, 63
		3. Elaboration of ideas	53, 62, 64, 67, 69, 81
		4. Critical thinking	38, 47, 51, 66, 71
		5. Metacognition	33, 36, 41, 44, 54, 55, 56, 57, 61, 76, 78, 79
	Resources management	6. Time and study environment management	35, 43, 52, 65, 70, 73, 77, 80
		7. Effort regulation	37, 48, 60, 74
		8. Peer learning	34, 45, 50
		9. Help seeking	40, 58, 68, 75

ción, CEAM II [31], due to it's been used widely in researches on self-regulated learning of students native speakers of Spanish. By applying CEAM II, to a group of Colombian university students of engineering, it was found that the psychometric indexes of the version applied were not satisfactory. The analysis of the results of this application, based on literature about psychometry and experts consultation, enabled concluding that translating and adapting the MSLQ to a different cultural context may lead to improper indexes of construct validity and reliability. It was decided to translate, adapt and validate the MSLQ to the educational context of Colombian university students. The new instrument should have, regarding to the MSLQ, the maximum equivalence as possible in linguistic, conceptual and metric aspects.

The aim of this article is to present the process of translation and adaptation, conducted to obtain the MSLQ-Colombia instrument from the MSLQ, and the information gathered about the psychometric properties of the new instrument. For the adaptation process, the International Test Commission (ITC) guidelines [38] were taken into account. The research question for this investigation was: is it possible to get an adapted and validated instrument, for the Colombian educational context, with the same psychometric properties of the original MSLQ? The results of this research indicate the new instrument, the MSLQ-Colombia, is valid and reliable, and presents validity and reliability indexes that are similar to the original MSLQ and other adaptations.

2. MSLQ dominance and dimensional structure

The MSLQ allows characterizing, at a specific time,

motivational aspects of the student regarding the learning tasks and the level of use of learning strategies in a class [17]. The semantic and syntactic definitions of the questionnaire constructs are based on the socio-cognitive theory of education and can be consulted in [1, 17]. The MSLQ dimensional structure proposes six sub-scales for the motivation scale and nine sub-scales for learning strategies [17] as shown in Table 1. The questionnaire has 81 items: 31 to characterize the motivational dimension and 50 to evaluate the usage of learning strategies.

MSLQ dominance is defined in terms of a class [23]; that is, each item of the questionnaire explores the reality of the student in a specific class. The reason for this rule is that both the motivation and the use of strategies can change considerably between classes. For example, the social context of each class, determined by variables such as the classroom environment or the desirability for the class topic, affects the student motivation to learn [2, 4, 11, 39]. Also the type of information of each class determines the pertinence of using some learning strategies; that is, the preference for using a strategy is conditioned by the nature of the contents of learning [40]. Speaking of a class, this domain is an advantage of the MSLQ over other questionnaires about motivation and learning strategies that have broader domains [34], for example, the learning process in general of the LASSI [18]. To fill the MSLQ the student agrees by a Likert acceptability scale of seven levels, common for all items, one if the item statement is not true on them and up to seven if the statement is completely true.

3. Methods

MSLQ adaptation for engineering students in Colombia was achieved considering the six cate-

gories proposed by Muñiz in [38], based on the International Test Commission (ITC) [24]. For more information about ITC guidelines please refer to the sources [24, 38].

3.1 MSLQ intellectual property

The first step in adapting the MSLQ was to consult about the intellectual property of the instrument. It was found that the MSLQ questionnaire is of public domain and that the only condition for usage is to make a proper bibliographic citation of the work in which the instrument was originated [23].

3.2 Linguistic and cultural adaptation

The work of linguistic and cultural adaptation of MSLQ began with a search of MSLQ versions translated into Spanish. The objectives were to apply a Spanish version of the MSLQ and determine whether that version was appropriate to characterize the motivation and learning strategies of the target population for this work. The pertinence of the questionnaire would be measured by internal validity analyses and by the reliability of the questionnaire implemented. By reviewing previous works of translation, adaptation and validation of MSLQ in educational contexts with students who were native Spanish speakers, different versions were found: the CEAM II of Rocés [41], the CMEA of Ramírez [34], the Cardozo version [42] and the MSLQ of Donolo [43]. Due to the CEAM II is an MSLQ validated adaptation widely cited in the literature and frequently employed in educational contexts different from Spain, which is the country of origin, it was decided to apply it out to a small sample of engineering students in Colombia.

The participants of this test were 119 Electrical and Electronic Engineering freshmen. The test was conducted in early 2012. The age of the students had a mean of 19.31 years and a standard deviation of 3.05 years. An exploratory factorial analysis was performed with the data collected by the method of principal axis and Oblimin oblique rotation. The analysis results indicated that:

- The items of the motivational scale generated 10 factors. Of these 10 factors only three matched the motivation sub-scales proposed by Rocés for CEAM II [41]: task value, anxiety and self-efficacy for performance. In terms of items, only 29% of the items related to motivation were grouped into the expected factors.
- Items in the learning strategies scale formed 14 factors; none of them matched the factorial structure proposed for the CEAM II.

The results above led to the conclusion that the CEAM II did not present proper validity indexes in the educational context of Colombian students who

filled it in and confirmed the necessity of performing the process of translation/adaptation of the MSLQ.

3.2.1 Translation of the MSLQ and adaptation process of the MSLQ-Colombia

An expert psychologist in the field of psychometrics and three members of the research team for this work performed a translation of the MSLQ items, from the original MSLQ version in English and the MSLQ translations into Spanish found in the literature. As suggested by the guidelines of the ITC [38], the native language of the four translators is Spanish; translators have wide experience in English, investigate engineering education subjects and are acquainted with the Colombian educational context.

A pilot test was performed with the translated version. The objectives of the pilot were to observe students behavior while filling in the questionnaire and to collect empirical data to perform an iterative and improvement process to achieve the linguistic and cultural adaptation of the initial questionnaire translation. The pilot involved 247 engineering students, 30.4% of the students were studying classes of the first five semesters and 69.6% classes of the last five semesters; their ages had a mean of 20.46 years and a standard deviation of 2.75 years.

In the pilot we noticed that some students exhibited signs of discomfort because they considered the questionnaire had too many questions, they constantly returned to the first page of the questionnaire to check the answers scale and several students expressed that the wording in some items was unclear. On average it took the students 25 minutes to answer the demographic questions and the questionnaire. The findings above enable to propose adjustments to the Questionnaire Application Protocol, the instrument answer format and the wording of some items.

The pilot also enabled to obtain data for an exploratory factor analysis in order to measure the construct validity of the translation we had at that moment. The factor analysis results indicated that motivational items showed a dimensional structure of seven factors: five equal to those proposed by Pintrich in the MSLQ (intrinsic goals, extrinsic goals, task value, control of learning beliefs and anxiety) and two factors that grouped separately the items of the MSLQ sub-scale of self-efficacy for learning and performance. The division of this sub-scale was presented as follows: items 6, 12, 15 and 29 were grouped in one factor; by analyzing the content of these items was found that all were questioning about self-efficacy expectancies for learning; and items 5, 20, 21 and 31 formed another factor, which were items related to expectancies of academic performance. This division into two com-

ponents of the self-efficacy for learning and performance sub-scale was also found in the work of Roces [41]. For the motivational dimension of this in-process version of translation/adaptation for Colombia, there were four items not grouped in the appropriate factor: 2, 18, 20 and 22; what suggested that they were items that required further reviews and adaptations.

For the learning strategies scale, items from the translated version showed a dimensional structure of 13 factors. Three factors were the same as those proposed for the MSLQ: critical thinking, rehearsal and organization of ideas; a factor that grouped the items of two proposed scales by separate in the MSLQ: peer learning and help seeking; and nine factors that grouped so indiscriminately the items of the other MSLQ sub-scales. 62% of the items of learning strategies, in the translation made in this work, continued without construct validity and required further efforts to bring the items into the Colombian educational context.

The following adaptation process was performed based on the results above:

1. Each factor of the structure found was reviewed with data from the pilot, even if the factor did not correspond to any sub-scale of the MSLQ. This review was performed seeking a possible explanation of why each factor was generated. In general, it was found that the possible causes for the factors that did not correspond to the structure of MSLQ were linguistic, for example, unclear wording of some items, grammatical issues, using common words or phrases in items belonging to different constructs, among others. For example, it was revealed that the eight items of the MSLQ that are written in reverse sense (items 33, 37, 40, 52, 57, 60, 77 and 80) formed only one factor, even when those items refer to different learning strategies. We decided that the solution for avoiding the appearance of this factor was to make an adaptation of meanings in order to give these eight items a positive sense.
2. Semi-structured individual interviews were made to 22 students who had filled in the questionnaire in the pilot. The interview focused on asking the students about the wording of the questionnaire items that were not grouped in the expected factor. Overall, the interviews offered cultural or contextual inputs that should be considered in order to change the items translation. For example, it was found that certain words or expressions used in the translation of the items had more than one meaning or were unfamiliar for the students who filled in the questionnaire. Also,

items that proposed rare study activities in the educational context for which the questionnaire was being adapted were discovered.

Likewise there were expressions that increased the possibility of emitting socially acceptable answers. For example, item 9 “It is my own fault if I do not learn the material in this course.” The expression “my own fault” was pointed out by several students as an indication of an undesirable negative image. Students also indicated that there were words whose meaning was abstract for them. For example, the word “ideas” used in items 42, 51 and 66, raised excessively general; so the students suggested replacing it with another word such as concepts, interpretations or approaches.

3. The wording of the translated questionnaire items, used in the pilot was changed based on the information obtained in the previous steps and the semantic definitions and operational forms of MSLQ constructs. The new items wordings focused on achieving a proper meaning adaptation instead of a literal translation of the original items.
4. In order to explore the translated/adapted items content validity, a group of university professors was requested to evaluate whether they considered each item appropriate and relevant to characterize the motivational construct or learning strategy for which it was proposed. The results of this analysis are presented in section 4.5.

In summary, the psychometric indexes obtained in the pilot and the results of interviews to a sample of the participating population in this test enabled to make linguistic and cultural adaptations to the items of the questionnaire in process of adaptation. Upon completion of the process of translation/adaptation, the questionnaire was applied to a population of engineering students in Colombia to confirm the psychometric properties of the adapted version of the MSLQ. The pilot application and the translation/adaptation process described above were conducted between 2012 and 2014.

3.3 MSLQ-Colombia psychometric properties research

3.3.1 Participating population and implementation

In order to determine the psychometric properties of the MSLQ-Colombia, the questionnaire was handed out to a sample of 852 engineering students at the Universidad Nacional of Colombia. The students were classified randomly by year, class, and career, given the intention of confirming the psychometric properties of the instrument and not making a study on the motivation and the strategies

used by the students in a particular class. Population was distributed as follows: 21.1% of the population studied Electrical Engineering, 22.2% Electronic Engineering, 21.9% Mechatronics Engineering, 10% Chemical Engineering, 10.6% Computing Engineering and 14.2% Mechanical Engineering. As to gender, 12.2% were women and 87.8% men; the ages of the participants were between 16 and 59 years, with a mean of 20.71 years and a standard deviation of 3.00 years. The questionnaire was made for classes in which students developed academic activities common in any engineering program as are lectures, laboratory practices, projects and problem solving, among others.

The questionnaire administration was performed by professors in charge nor the development or assessment of the classes in which the instrument was implemented; it was in the classroom and during the class. The implementation was made in the fifth week of the academic term, in a time that students had already had the opportunity to use learning strategies in the activities of the class; also, it was in a time that students did not know the final results of their learning activity and therefore, it was appropriate to evaluate several motivational aspects related to the class. The instructions for filling in the questionnaire were the same for all participating students and were read directly from the form. The instructions indicated students that their participation was voluntary, that their names and answers were confidential and that if they agreed to participate should sign a consent form authorizing to use their answers to develop this research. Due to the difficulties observed in the application protocol, during the pilot, there was a five-minute break between the questions about motivation and the question about learning strategies. This break sought to avoid tiredness of the participants during the questionnaire session. The answers scale was added to the header of each page of the questionnaire, in order to avoid the student to return to consult it on the first page of the instrument. Average time of the questionnaire completion was 30 minutes.

3.3.2 Statistical analysis

Empirical data collected from engineering students were useful to calculate the dimensional structure and reliability indexes of the adapted questionnaire. The dimensional structure and reliability indexes of the MSLQ are available at [17, 23]. The psychometric properties equivalence between the MSLQ-Colombia and the MSLQ was evaluated by comparing the dimensional structures and reliability indexes of both instruments.

The dimensional structure of the MSLQ-Colombia also helped confirming its construct validity.

“Construct validity signifies the extent to which an instrument actually measures the theoretical construct or trait that it purports to measure” [44]. The dimensional structure of the MSLQ-Colombia was found from an exploratory factor analysis using the method of principal axis for extracting the factors and Kaiser K1 rule for factors retention. Before performing the factor analysis, the Kaiser-Meyer-Oklin (KMO) index and Bartlett test of Sphericity were calculated to determine whether the correlation matrix of the items of each scale of the MSLQ-Colombia was factorable. The initial matrix generated by the factor analysis was rotated using the Oblimin method. Non orthogonal rotation method was used because a dependence between the resulting factors is expected [45] caused by the nature of the variables explored in the adapted questionnaire. It was considered that the item belongs to the factor in which the item had the higher factor loading (absolute value), if the loading value is greater than or equal to 0.30 because the sample population was greater than 350 students [46].

The reliability of the adapted questionnaire was interpreted as the internal consistency of the sub-scales found in the factor analysis. Internal consistency was calculated by finding the Cronbach’s Alpha index for each sub-scale. This index determines the extent to which the items of a subscale are intercorrelated. Additionally, item discrimination in its sub-scale was calculated by means of two indexes: the correlation Item - total corrected and the Cronbach’s Alpha of the sub-scale if the item was removed. The internal consistency indexes of MSLQ-Colombia and the items discrimination indexes were compared with the rates reported for the MSLQ. The results of these analyzes are presented in the following section.

4. Results

4.1 Construct validity of the motivational dimension in the MSLQ-Colombia

The index of sampling adequacy of correlation matrix, for the items about motivation, was KMO = 0.901 and Bartlett’s test of sphericity indicated statistical significance (p-value <0.001). These results showed that the sample was appropriate for factor analysis and the null hypothesis that the correlation matrix was an identity matrix must be rejected. The factor analysis of the items about motivation and rotation of the factor matrix revealed a matrix structure of seven factors explaining 64.7% of the variance.

The dimensionality of the items about motivation suggested an identical structure of the MSLQ, except for the MSLQ items in the sub-scale of self-efficacy for learning and performance. This sub-

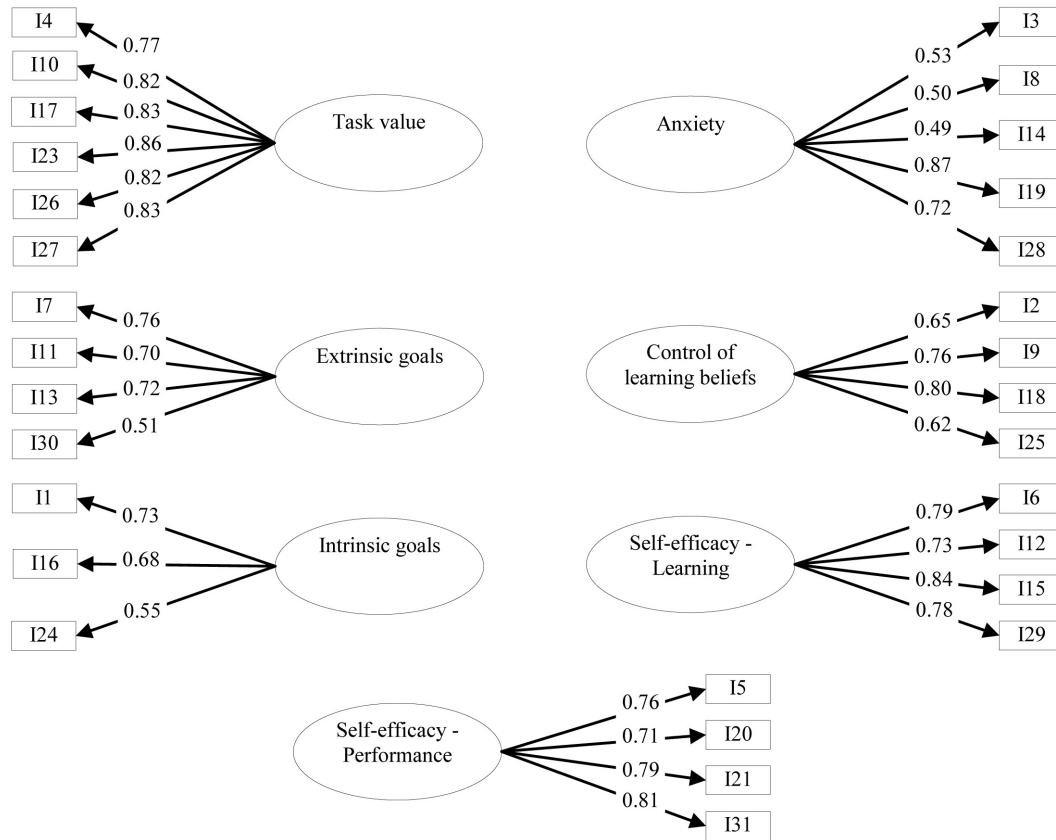


Fig. 1. Factorial structure of the MSLQ-Colombia motivation scale. In this figure, every square represents an item of the questionnaire (for example: item 4 = I4); the ovals symbolize the motivation subscales, in other words, the factors found in factor analysis (for example: Task value or Anxiety); the arrows indicate the item belongs to the subscale which is being associated to by the arrow, that is, the item presented the highest factor loading in the subscale connected (for example: items 4, 10, 17, 23, 26 and 27 presented their highest factor loading in factor “Task value”); and the overlapped number in each arrow is the absolute value of the factor loading that the item presented in the subscale or factor (for example: item 4 presented a load value of 0.77 in factor “Task value”).

scale, the same as occurred in the pilot, was separated into two factors: a factor with the items 6, 12, 15 and 29 that form a sub-scale related to student self-efficacy expectancies for learning and another factor with the items 5, 20, 21 and 31 that define the sub-scale of expectancies for academic performance in class.

In terms of items, item 22 was the only one that had a higher factor loading in an unexpected factor. The loading of this item was 0.61 in the sub-scale of the task value, while in the sub-scale of intrinsic goals, for which it is designed, the factor loading was 0.42. This result meant further analysis to determine whether the item 22 was removed from the MSLQ-Colombia. For this, the internal consistency of the task value sub-scale was analyzed, including and

removing item 22. It was found that the internal consistency of the sub-scale increased when the item was removed, which is why it was decided to skip this item in the MSLQ-Colombia. Due to this removal, a new factor analysis for the items of the motivation scale (excluding item 22) was performed. The analysis confirmed the factorial structure and factor loadings of the items (absolute value) showed in Fig. 1. In short, the motivation scale presents proper construct validity with the same factorial structure of the MSLQ, except for self-efficacy subscales.

Table 2 shows the percentage of variance explained by the factors of the dimensional structure of the motivation scale of the MSLQ-Colombia.

Table 2. Variance explained by the factorial structure of the MSLQ-Colombia motivation dimension

	Task Value	Anxiety	Extrinsic goals	Control of Learning Beliefs	Intrinsic goals	Self-efficacy for learning	Self-efficacy performance
Variance (%)	25.69	11.33	8.98	6.42	5.11	3.83	3.35

4.2 Reliability of the motivation dimension sub-scales

Internal consistency reliability of the MSLQ-Colombia sub-scales was found through Cronbach's Alpha. In works with research purposes, Alpha values over 0.60 are considered acceptable and higher than 0.85 excellent [47]. According to this criterion, the internal consistency of the task value sub-scale (0.92) is excellent, while the consistencies for the anxiety sub-scales (0.75), extrinsic goals (0.76), control of learning beliefs (0.79), intrinsic goals (0.70) and self-efficacy expectancies for performance (0.81) were good. The internal consistency of the self-efficacy expectancies for learning sub-scale (0.60) was lower but has an acceptable value. In short, the reliability of the MSLQ-Colombia motivation dimension sub-scales was appropriated.

For each item was calculated the item correlation with the total score of the sub-scale, removing the item. The value of this correlation is considered adequate if it is greater than or equal to 0.25 [47]. For the items of the motivation sub-scales it was found that the lowest value was 0.25 (item 12). Finally, the Cronbach's Alpha consistency index of the sub-scale was calculated, if the item is removed. The consistency index increased in not a single case of the sub-scale if any of the items was removed.

4.3 Construct validity of the learning strategies dimension in the MSLQ-Colombia

The KMO index of the correlation matrix for the items of learning strategies was $KMO = 0.903$. Bartlett test of sphericity was statistically significant (p -value < 0.001). From these results we proceeded to perform the factor analysis. The results indicated that the matrix structure of the learning strategies dimension consists of eleven factors explaining 60.94% of the variance. It is worth remembering that the factorial structure proposed for the MSLQ consists of nine factors. When comparing factorial structures of the original MSLQ and of the adapted MSLQ was found that: they match five sub-scales: elaboration of ideas, organization of ideas, rehearsal, effort regulation and critical thinking.

The structure found for the MSLQ-Colombia also showed that the MSLQ metacognition sub-scale was divided into three sub-scales for the adapted questionnaire. Each sub-scale matches one of the three general processes involved in a self-regulated [17] metacognitive activity: planning (items 36, 54, 61 and 78), monitoring (items 33, 76 and 79) and study method regulation (items 44 and 56). This result would indicate that, in the context of engineering Colombia, students associate MSLQ

items about metacognition to three different processes. The factor analysis also indicated that the MSLQ time and study environment management sub-scale was understood by the target population of this adaptation as two different sub-scales: time to study management (items 43, 52, 70, 77 and 80) and study environment management (items 35 and 65). Additionally, the structure showed that MSLQ peer learning and help seeking sub-scales come together in one sub-scale in the MSLQ-Colombia (items 34, 40, 45, 50, 58, 68 and 75).

In terms of items, it was found that four items (41, 55, 57 and 62) had its highest loading in unexpected sub-scales. The item 62, designed for the elaboration of ideas sub-scale, has a factor loading of 0.531 in the critical thinking sub-scale and 0.411 in elaboration of ideas. Items 41, 55 and 57 of the metacognition sub-scale, about monitoring process, had their highest factor loading in the elaboration of ideas sub-scales (0.395), metacognition—planning (0.488) and study environment management (0.454); respectively. According to these results, for the dimension of learning strategies, 46 of 50 items had the highest value of factor loading in the expected sub-scale or in a sub-scale where was found some logical reason to be there (see discussion section).

Additional analyzes were conducted to determine whether it was pertinent to omit the four items from the MSLQ-Colombia that did not grouped in the expected sub-scale. For example, factor analysis and internal consistency tests were conducted with 46 items that grouped properly, including one or more of the items that did not grouped in the expected sub-scale. In factor analysis it was confirmed that none of the four items in matter presented its highest factor loading in the expected sub-scale. Additionally, it was found that the internal consistency of the sub-scales, in which these items were grouped, increased when the item was removed. Finally, we reviewed the constructs definitions of the sub-scales, on which these items grouped, and the purpose of each item. It was found that in all four cases the semantic definitions of the sub-scales on which they grouped were considerably far from the purpose of each item. Given the above, we decided omitting items 41, 55, 57 and 62 from the MSLQ-Colombia. A new factor analysis with the 46 items of the learning strategies scale was performed and factorial structure and factor loadings (absolute value) presented in Fig. 2 were confirmed. In short, the learning strategies scale presents proper construct validity with a factorial structure similar to the MSLQ.

The importance of each sub-scale related to learning strategies was measured by the percentage of variance explained by each factor. The results are shown in Table 3.

Table 3. Variance explained by the factorial structure of the MSLQ-Colombia learning strategies dimension

	TS	PL	EL	E	R	SE	MP	CT	OI	MM	MSmet
Variance (%)	21.94	7.30	5.80	5.17	4.00	3.47	3.03	2.80	2.59	2.52	2.32

TS: Time to study, PL: peer learning, EL: elaboration of ideas, E: effort regulation, R: rehearsal, SE: study environment, MP: metacognition—planning, CT: critical thinking, OI: organization of ideas, MM: metacognition—monitoring, MSmet: metacognition—study method.

4.4 Reliability of the sub-scales of the learning strategies dimension

The reliability of the MSLQ-Colombia learning strategies dimension sub-scales was appropriated. Internal consistency reliability of the sub-scales of elaboration of ideas (0.83), peer learning (0.82), time to study (0.83), study environment (0.82) and effort (0.84) had moderate to high values. The sub-scales of organization of ideas (0.70), rehearsal (0.76),

metacognition—planning (0.73) and critical thinking (0.75) had moderate values and sub-scales of metacognition—monitoring (0.61) and metacognition—study method (0.58) had moderate to low consistency indexes.

For each item about learning strategies the item correlation was calculated with the total score of the sub-scale when removed the item. The lowest correlation was 0.34 for item 33. Finally, the Cronbach’s

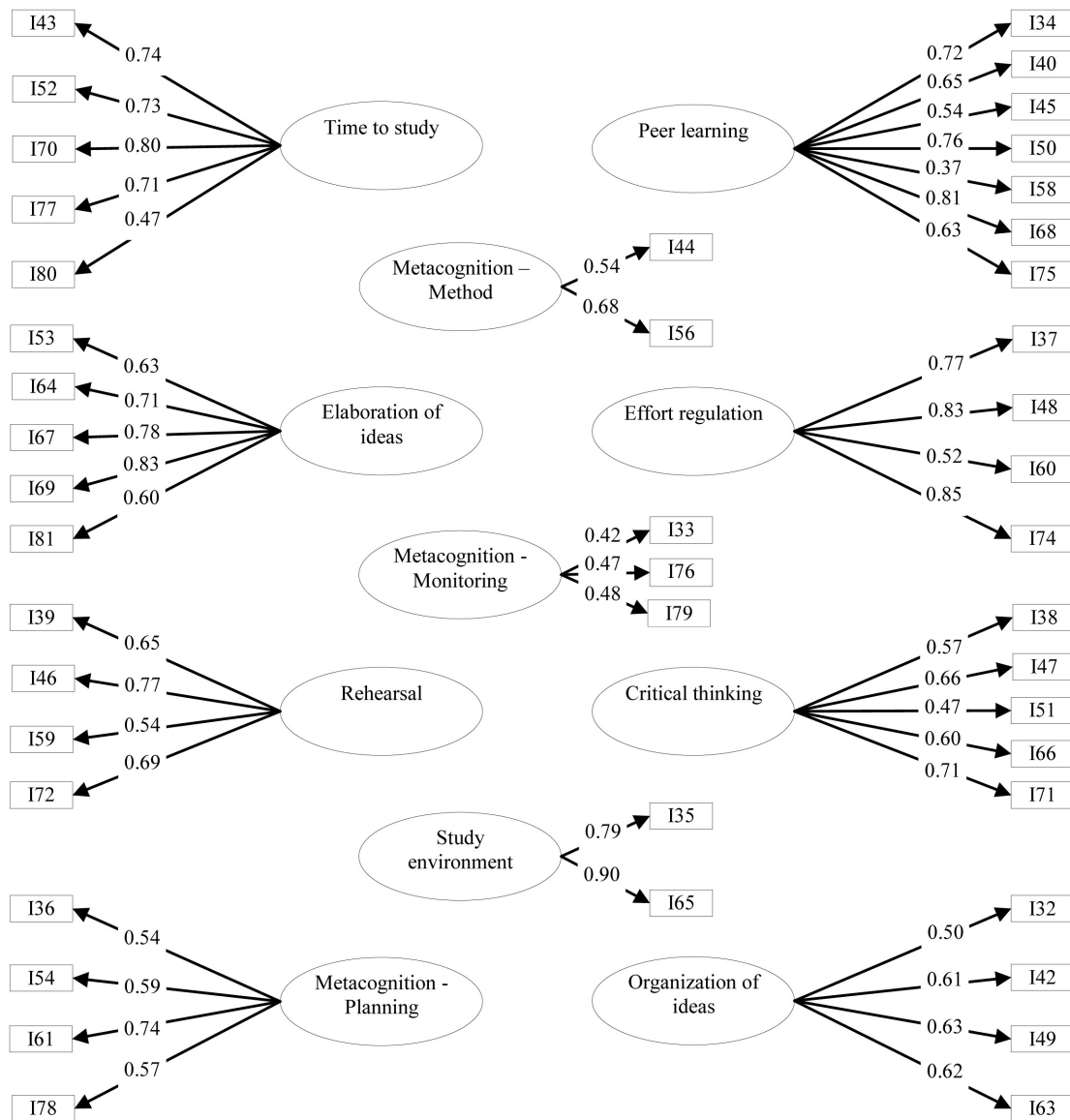


Fig. 2. Factorial structure of the MSLQ-Colombia learning strategies scale.

Alpha consistency index of the sub-scale when removing any of the items was calculated. It was found that when removing item 73 of the time to study management sub-scale, the consistency index of that sub-scale increased from 0.75 to 0.83. To decide whether to remove this item, the factor loadings posing in different sub-scales and their purpose was verified. It was found that item 73 had a similarly low factor loading in three sub-scales: time to study (0.38), effort (0.33) and meta-cognition-monitoring (0.32), meaning that this item is understood in the target population as three different constructs and therefore was appropriate to remove it from the MSLQ-Colombia. Due to this elimination, it was necessary to conduct a new factor analysis for the items in the learning strategies scale excluding item 73. The analysis confirmed the structure and the factor loadings showed in Fig. 2.

4.5 Content validity of the MSLQ-Colombia

In order to explore the translated/adapted items content validity, 12 university professors were requested to evaluate whether they considered each item appropriate and relevant to characterize the motivational construct or learning strategy for which it was proposed. Each item was individually analyzed by each expert based on semantic and operational definitions of MSLQ constructs. Each expert judge assessed whether the item was appropriate in a range of one to five: one as a non-appropriate item and up to five as a totally appropriate item for the sub-scale. A pertinence average, inter-rater, higher than three point five (3.5) was defined as a criterion of validity of the item. The pertinence average of all items was from three point seventy-five to five (3.75–5.00). In short, the opinion of expert judges indicated that the translated/adapted questionnaire had appropriate content validity in the context of engineering education in Colombia.

5. Discussion

5.1 Comparison of psychometric properties of motivation scales in MSLQ-Colombia and in the MSLQ

The results of construct validity for the motivation scale of MSLQ-Colombia indicate the dimensional structure of the new questionnaire is identical to the MSLQ, except for some changes in the dimensional structure in the subscale of self-efficacy expectancies for learning and performance, and the semantic definition in the intrinsic goals subscale.

The separation of the sub-scale of self-efficacy expectancies into two sub-scales indicate that in the context of engineering students in Colombia, learn-

ing expectancies are not equivalent to the expectancies of a good academic performance. That is, the students' beliefs about their ability to understand the class topics do not match those beliefs of getting good academic performance. The separation of this sub-scale also occurred in the Roces [31] adaptation work in Spain. This result lead to question whether there are common constraints, even in different cultural contexts, that make students not equally able to acquire new knowledge and get good academic performance.

In MSLQ-Colombia the intrinsic goals sub-scale contains three items (1, 16 and 24), while in the MSLQ contains four items (1, 16, 22 and 24). According to this result, the definition of intrinsic orientation in MSLQ-Colombia includes the challenge (item 1), curiosity (item 16) and the determination of learning new things (item 24) as reasons that the student may have to want to be involve in the learning process. Item 22 was referring to deeply understand the class topics, but had to be removed from the adapted questionnaire due to its low factor loading in the intrinsic goals grouping; implying that this goal cannot be measured with MSLQ-Colombia. It draws a lot of attention that the item 22 presented the highest factor loading in the task value subscale; this result is the same as the result found in other adaptations [31, 32, 42].

The results of the internal consistency indexes of the sub-scales of motivation to learn indicated that it was not necessary to remove items from MSLQ-Colombia. This result indicates that different items of each sub-scale would measure, great extent, a single dimension or property of the motivation to learn of the students.

5.2 Comparison of psychometric properties of learning strategies scales in MSLQ-Colombia and in the MSLQ

The factor analysis of the items about learning strategies led to the conclusion that the dimensionalities of the MSLQ-Colombia and the MSLQ are the same for the sub-scales of elaboration of ideas, organization of ideas, rehearsal, effort regulation and critical thinking. The factorial structure of the scale of learning strategies also indicated that the MSLQ sub-scale about time and study environment is divided into two sub-scales in the MSLQ-Colombia. A sub-scale refers to the time to study resource management that includes items asking about the management of planning, scheduling and time to study a class and another sub-scale that refers to the study environment management that gathers items about choosing an appropriate place to study in order to increase attention in tasks. This result, though it has not been found in other adaptations, seems reasonable based on the theoretical frame-

work related to MSLQ [1] learning strategies: the two sub-scales found in this work are about the management of two different resources that the student have: time and study environment. That is, a student should ideally manage properly both resources; however, it could happen that they manage very well just one of them. Given this analysis, the factorial separation was considered reasonable.

The factor analysis of the items about learning strategies also concluded that the MSLQ-Colombia characterize three components of the metacognition strategy separately: learning activity planning, study process monitoring and regulating the method of study. The MSLQ authors expected to find this factorial separation when validated the questionnaire, however this separation did not occur in the context of US undergraduate students [23]. In MSLQ-Colombia the planning sub-scale includes items about goals setting and analysis of the learning task before starting the study processes. The sub-scale of monitoring the learning activity relates to the monitoring of the attention in class (item 33) and the control of attention during the study activity in order to identify when the class topics are not understood (items 76 and 79). In the MSLQ monitoring the learning activity, beyond what was already indicated for the MSLQ-Colombia, also includes self-interrogation and self-observation (items 41, 55 and 57) to determine whether the topic studied is being understood; it was necessary to remove these items from the MSLQ-Colombia. In other MSLQ adaptations these three items have also been removed [32, 36] or have been grouped into sub-scales different from metacognition strategies [41, 42]. As a result, the definition of metacognitive monitoring in MSLQ-Colombia is partially equivalent to the MSLQ. Finally, in the MSLQ-Colombia the metacognitive regulation sub-scale refers to adjust the method of study when the topics are not understood or when it is required by the conditions of the class (items 56 and 44).

In addition, factor analysis showed that two sub-scales of the MSLQ are grouped in a single factor in MSLQ-Colombia; these sub-scales are: peer learning and help seeking. This result indicates that the target population of this study understood as one strategy either when studying with others, in order to expand the points of view in the face of a topic or when seeking help from others in the case of not knowing something or not understanding the class topics of study. This result is consistent with the findings of Rocés [31] in Spain and Cardozo [42] in Venezuela in their MSLQ adaptations work.

The removal of item 62 from the scale of learning strategies implies that the semantic definition of

elaboration of ideas, in MSLQ-Colombia does not include the technique of establishing relations between the concepts of a class and the ones related to other classes. Also, from the results of the internal consistency indexes of the sub-scales of learning strategies it was necessary to remove the item 73 from the MSLQ-Colombia. This removal implies not to include time management in the time to study sub-scale in order to attend to class. The reason for the low consistency of this item may be that is the only item in the sub-scale of time to study that is not concerned with time management for extracurricular activities (“I regularly attend to this class”). Also in other studies of adaptation of the MSLQ the target population has not understood this item as time management. For example, in Rocés validation this item was grouped in the sub-scale of learning constancy [41], the work of Cardozo [42] it was grouped in a sub-scale called self-regulation and the results of Martinez [48] this item formed a single factor. Even on the results of the MSLQ confirmatory factor analysis, in the original work, this item also had low factor loading (0.37) in the sub-scale of time and study environment management.

5.3 About the total variance explained and the internal consistency indexes of the MSLQ-Colombia

The number of factors extracted for each scale on the MSLQ-Colombia questionnaire, in factor analysis, was enough to reach the criterion proposed for Social Sciences studies, which suggests continuing extracting factors until achieving 60% of the total variance explained [46]. The subscales of task value and time to study are the ones that explain the most the total variance of items related to motivation and learning strategies, respectively. This result indicates these two subscales are the most important to describe the relations between all variables measured by the MSLQ-Colombia. The total variance explained presents higher values in comparison with other adaptations of the MSLQ [29, 31]. On the other hand, the MSLQ-Colombia reliability, understood as the internal consistency of the subscales in the questionnaire, showed indexes between acceptable and excellent values. This result indicates the different items of each subscale might be measuring, to a great extent, just one dimension or trait of the motivation to learn or learning strategies.

6. Conclusions

The methods and results of this research responded to the question: is it possible to get an adapted and validated instrument, for the Colombian educational context, with the same psychometric proper-

ties of the original MSLQ? The new instrument, MSLQ-Colombia, is valid and reliable, with psychometric properties similar to the original MSLQ and other adaptations. The dimensional structure of the MSLQ-Colombia has 7 subscales for epistemic motivation and 11 subscales for learning strategies. The dimensional structure is slightly different from the hypothesized for the original MSLQ, but justifiable by the cognitive theory on self-regulated learning. At an item level, the MSLQ-Colombia has 30 items to characterize epistemic motivation and 45 items to characterize the use of learning strategies.

The MSLQ-Colombia solves the problematic situation of not having a complete adaptation and validation of the MSLQ in Spanish to characterize the motivation and learning strategies employed by the Colombian university students. Due to linguistic and cultural similarities between Spanish speaking countries, the authors consider the MSLQ-Colombia could be useful in educational contexts different from Colombian context. Therefore, we recommend conducting a pilot test before massively using the questionnaire, in order to confirm if the instrument still has the same psychometric properties. Should the results not be satisfactory, it is suggested following the method described in this article, with the aim of attaining a new valid and reliable questionnaire.

The literal translation of the MSLQ was not enough to achieve validity and reliability of the new instrument, proving that the careful translation of a psychometric instrument is necessary but not enough, and that the items must be linguistically and contextually adapted to adjust the meaning into the new context [24, 38]. The data gathered from the factor analysis during the pilot test provided the most important asset for the linguistic adaptation, mainly, to improve the items wording; the interviews to the students provided the most important assets for the contextual adaptation.

These results are empiric evidences, useful for the international academic community because they can be compared to other studies, whose purpose is adapting and validating the MSLQ; likewise, the results provide information for those who may use the MSLQ-Colombia, easing the comprehension of their studies results.

Although one of the main limitations of this adaptation is that the target population and the population sample were reduced, given the importance of characterizing the motivation and the strategies used by undergraduate students, it is pertinent to continue exploring the MSLQ-Colombia psychometric properties in students not only from engineering careers. Also, the participating sample population in this work belongs only to engineering programs at the Universidad Nacional

de Colombia, so it is advisable to make sure if the social context might influence the results presented, testing engineering students from other Colombian educational institutions. As evidence of external validity of the MSLQ-Colombia was found a correlation between academic performance and the motivational level and use of learning strategies of the participating population in this research, however these results are not provided because they exceed the scope of this paper.

The MSLQ-Colombia is free and is available to the international academic community; to get a copy of the questionnaire, please send your request via email to any of the authors of this article.

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