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Factorial Composition of the Self-efficacy Problem Solving and Communication Scale in Mexican University Students

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Abstract: The present study aims to investigate whether the psychometric results proposed by [1] for the Self-efficacy Problem Solving and Communication Scale replicate. The total sample was of 2059 subjects; 891 women and 1168 men, students of the degrees offered at the Autonomous University of Chihuahua, with an mean age of 18.21 years (SD = 0.74). The factorial structure of the questionnaire was analyzed by confirmatory factor analysis. The analysis shows that a two-factor structure is feasible and appropriate. The two-factor structure (problem solving and scientific communication), based on statistical and substantive criteria, has shown adequate fit indicators of reliability and validity. Furthermore, the results of the factor analysis conducted with subsamples, indicate the existence of strong evidence of the stability of the factor structure. Future research should replicate these findings in larger samples.

Keywords: Self-efficacy, Factorial Structure, Construct Validation, Structural Equation

1. Introduction

Bandura [2] in his social cognitive theory emphasizes the role of self-referential phenomena as the way in which the individual is able to act in his environment and consequently transform it, individuals create and develop self-perceptions about their ability, perceptions that become the means by which they pursue their goals and make their decisions [3, 4]. That is, the way people act, is the product of the intervention of their beliefs about what they are capable to do.

The beliefs that people have about themselves represent a basic factor for the achievement of their activities or in their decision-making that they will face throughout their lives. The greater perceived efficacy, the greater degree of effort invested and the greater persistence in achieving the goal are very important situation for a person, who is in a learning process, to be successful [5, 6]. Definitely, self-efficacy beliefs are a cognitive mechanism that mediates between knowledge and action and determines, among other factors, the success of the own actions [7-9].

As an example of the importance of self-efficacy in the academic sphere, we can say that this reveals why people with the same level of skills and knowledge present behaviors and/or different results, or why people act in dissonance with their skills [6, 10]. Therefore, self-efficacy beliefs in one's ability are indispensable to master the academic activities; since students that trust in their capabilities are more motivated to achieve their goals [11]. Hence the importance that education strengthens the development of academic competence in students and encourages skills that enables them to believe in their own abilities [7, 8].

For all the above, this research is based on the premise that the perceived academic self-efficacy is an important mediating factor in how people feel, think, motivate and behave; so measuring the perception of academic self-efficacy in the learner is extremely important in the study of how to facilitate progress and educational success, as well as to minimize the risk of leaving school [12, 13].

This paper analyzes the internal consistency and the factor structure of a self-report instrument that allows to identify academic behaviors in the field of Problem Solving and scientific Communication, whose level of perceived self-efficacy in the students represent an opportunity area; in relation to the rest of the students, providing evidence and data that promote the educational intervention within a perspective of attention to diversity in the classroom.

The present instrumental study [14] is aimed to provide empirical support for the factorial division proposed by [1] for the Self-efficacy Problem Solving and Communication Scale; which it is justified by the importance of checking the factorial structure of the instrument and the psychometric equivalence of it in different groups; since in the context of intergroup comparison, it is essential to consider the need to conduct the adaptation of an instrument of psychological measure that would meet all criteria of equivalence, but above all, consider whether the same factorial structure is applicable to different groups of subjects or, more generically, to different populations [15].

2. Method

2.1. Participants

The sample of 2059 subjects, 891 women and 1168 men was obtained by a convenience sample, trying to cover the representation of the different degrees offered at the Autonomous University of Chihuahua. The age of participants ranged between 17 and 20 years, with a mean of 18.23 and a standard deviation of 0.74 years.

The sample was randomly divided into two parts using the Statistical Package for Social Sciences (SPSS) version 18.0; in order to perform parallel studies to corroborate and verify the results (cross validation).

The subsample 1 was composed by 1009 subjects. Ages ranging between 17 and 20 years, with a mean of 18.23 and a standard deviation of 0.74 years.

The subsample 2 was composed of 1050 subjects. Ages ranging between 17 and 20 years, with a mean of 18.22 and a standard deviation of 0.74 years.

2.2. Instrument

The self-efficacy in problem solving and scientific communication was measured by the Self-efficacy Problem Solving and Communication Scale [1]. This questionnaire consists of an 11-item scale with two subscales: problem solving (6 items) and scientific communication (5 items). According to previous studies [16, 17], due to the fact that in the Mexican academic context students are commonly assessed by a scale from 0 to 10, in the present study a Likert-type scale from 0 to 10 was chosen. For each domain (item) of the problem solving and scientific communication competences (subscales), the participants were asked about how capable they feel, how much interest they have, and if they would make an effort to change how capable they will be to... Therefore, all the participants responded to each of the 11 items of the questionnaire in the three different scenarios: (a) Scenario of perceived ability, responding in the context "how capable I feel to… to manage in each of the domains of the competences above mentioned"; (b) Scenario of interest in being able, responding in the context "how much interest I have in being able to... to manage in each of the domains of the competences above mentioned"; and (c) Scenario of change to be able to, responding into the context "if I would make an effort to change, how much capable I will be able to... to manage in each of the domains of the competences above mentioned".

2.3. Procedure

Students of the degrees offered at the Autonomous University of Chihuahua were invited to participate. Those who agreed to participate signed the consent letter. Then, the instrument described above was applied using a personal computer (administrator module of the instrument of the scales editor of typical execution), in a session of about 30 minutes in the computer labs of the participating faculties.

At the beginning of each session students were given a brief introduction on the importance of the study and how to access the instrument. They were asked the utmost sincerity and they were guaranteed the confidentiality of the data obtained. Instructions on how to respond were in the first screens; before the first instrument item.

At the end of the session they were thanked for their participation. Once the instrument was applied, data was collected by the results generator module of scales editor, version 2.0 [18].

2.4. Data Analysis

The first step in analyzing the psychometric properties of the questionnaire was to calculate the mean, standard deviation, skewness, kurtosis and discrimination indexes of each item. Then remove of the scale those who obtain a kurtosis or extreme asymmetry, or a discrimination index below 0.35.

Then, were submitted to comparison two measurement models: Model 1 (M1), one-factor model and Model 2 (M2), which responds to a two-factor structure according to the original distribution of the items of the questionnaire.

To conduct the confirmatory factorial analysis, AMOS 21 software was used [19], variances in terms of error were specified as free parameters, in each latent variable (factor) a structural coefficient was set associated to one, so that scale was equal to one of the observable variables (items). The estimated method used was the maximum credibility; following the recommendation of Thompson [20], so when the confirmatory factorial analysis is used, it is necessary to verify not only the fit of the theoretical model but it is recommended to compare the fit indexes of some alternative models to select the best.

To evaluate the adjustment model, statistical chi-squared, the Goodness-of-fit index (GFI), and the root mean square error of approximation (RMSEA) were used as absolute adjustment measures. Adjusted goodness of fit index (AGFI) the Tucker-Lewis Index (TLI), the comparative fit index (CFI) as measures of increasing adjustment. The chi-squared fit index divided by degrees of freedom (CMIN/GL) and the Akaike Information Criterion (AIC) as adjusting measures of Parsimony [21, 22].

Subsequently, following the recommendations of [15] was made an analysis of the factorial invariance of the questionnaire for the subsamples, taking as a base the best measurement model obtained in the previous stage.

Finally was calculated the reliability of each of the dimensions, of the measurement models obtained in each subsample, through Cronbach's alpha [23, 24] and Omega coefficient [25, 26].

3. Results

Descriptive analyzes and discrimination indexes.

Table 1. *Descriptive Analysis and discrimination indexes of the questionnaire items "Self-efficacy Problem Solving and Communication Scale ."Total sample.*

Item	M	SD	AS	CU	$r_{i\text{-total}}$
Item 1	7.69	1.49	-.92	1.41	.67
Item 2	7.79	1.54	-.85	1.13	.73
Item 3	7.50	1.64	-.92	1.38	.69
Item 4	7.94	1.67	-1.04	1.31	.59
Item 5	7.68	1.55	-.87	1.00	.73
Item 6	7.04	1.76	-.84	.95	.71
Item 7	7.63	1.68	-.99	1.38	.71
Item 8	7.60	1.87	-1.05	1.25	.59
Item 9	7.18	1.75	-.92	1.50	.67
Item 10	7.57	1.72	-1.02	1.46	.56
Item 11	7.67	1.52	-.91	1.25	.72

Note: M = mean; SD = standard deviation; AS = asymmetry; CU = kurtosis; ri-Total = total-item correlation corrected.

In the Table 1 are summarized the results of the descriptive analysis and the discrimination indexes (total-item correlation corrected) of each of the 11 items on the questionnaire in the total sample. The answers to all items reflect mean scores ranging between 7.04 and 7.94, and standard deviation offers, in all cases, higher values over 1.40 (within a response range between 0 and 10). All values of skewness and kurtosis are within ± 2.5; so is inferred that the variables are reasonably fit to a normal distribution. Regarding discrimination indexes of all items, they discriminate satisfactorily by discrimination indexes above .35 [27].

Confirmatory Factorial Analysis.

The global results of the confirmatory factor analysis in the subsample 1 (GFI .840; RMSEA .132; CFI .874) and the subsample 2 (GFI .884; RMSEA .114; CFI .900) for M1 model corresponds to a unifactorial distribution of the items in the questionnaire, indicate that the measurement model, in both subsamples, is not acceptable (Table 2).

The factor of the model M1 explains approximately the 55.08% of the variance in the first sub-sample and the 53.69% of the variance in the second subsample. Furthermore, 3 of the 11 items (items 4, 8 y 10) in the first subsample and 4 of the 11 items (items 4, 8, 9 and 10) in the second subsample, saturate under .70 in their intended dimension.

Table 2. *Absolute, incremental and Parsimony fit indexes for the generated models. Subsamples 1 and 2.*

	Absolute indexes			Incremental indexes			Parsimony indexes	
Model	χ^2	GFI	RMSEA	AGFI	TLI	CFI	CMIN/DF	AIC
First factor solution (subsample 1)								
M1	821.985*	.840	.132	.760	.843	.874	18.681	865.985
M2	163.629*	.971	.055	.953	.973	.980	4.091	215.629
Second factor solution (subsample 2)								
M1	646.232*	.884	.114	.827	.875	.900	14.687	690.232
M2	150.679*	.974	.051	.957	.975	.982	3.767	202.679

Note: * $p < .05$; GFI = goodness of fit index; RMSEA = root mean square error of approximation; AGFI = adjusted goodness of fit index; TLI = Tucker-Lewis index; CFI = comparative fit index; CMIN/DF = chi-squared fit index divided by degrees of freedom; AIC = Akaike information criterion

Table 3. *Standardized solutions confirmatory factor analysis for the M2 Model. Subsample 1 and 2.*

	Subsample 1		Subsample 2	
Item	**F1**	**F2**	**F1**	**F2**
Factor weights				
1 Apply different observation techniques to solve problems	.71		.72	
3 Distinguish the different types of systems	.78		.75	
5 Use different methods to establish alternatives in solving problems	.80		.83	
6 Apply the systemic approach in various contexts	.80		.78	
9 Use statistics in the interpretation of results and knowledge construction	.73		.70	
11 Analyze the different components of a problem and their interrelations	.78		.79	
2 Collect analyze and apply information from different sources		.82		.80
4 Handle documentary and electronic resources that support communication and information search		.63		.63
7 Develop writings from research processes		.82		.77
8 Handle and apply software packages to develop documents, presentations and databases		.65		.61
10 Read and interpret texts		.70		.70
Correlations between factors				
F1	-		-	
F2	.81	-	.85	-

Note: F1 = problem solving; F2 = scientific communication.

The overall results of the confirmatory factor analysis in the first (GFI .971; RMSEA .055; CFI .980) and second subsample (GFI .974; RMSEA .051; CFI .982), of the second model tested (M2) that corresponds to a two-dimensional structure of the questionnaire, indicates that this measurement model is better than the previous model and its fit is optimal (Table 2). The two factors of this model explain altogether, in both subsamples more than 62% of the variance.

Furthermore according to the results of Table 3 only 2 of the 11 items, in both subsamples, saturate under .70 in their intended dimension. Also was observed moderate intercorrelations among factors, showing a not very adequate discriminant validity between them.

Invariance of the factor structure between subsamples.

The fit indexes obtained (Table 4) allow to accept the equivalence of the basic measuring models between the two subsamples. Although the value of Chi-squared exceeds the required to accept the hypothesis of invariance, the GFI=.973, CFI=.981, RMSEA=.038 y AIC=418.308 indexes contradict this conclusion allowing us to accept the base model invariance (unrestricted model).

Adding to the base model restrictions on factorial loads the metric invariance was characterized. The values shown in Table 4 allow accepting this level of invariance. The goodness of fit index (GFI .972) and root mean square error of approximation (RMSEA .036) continue to provide convergent information in this direction. Also, the Akaike Information Criterion (AIC 412.231) and Bentler comparative fit index (CFI .981) do not suffer large variations over the previous model. Using the criteria for the evaluation of the nested models proposed by [28], who suggest that if the calculation of the difference of the CFI of both nested models diminish in .01 or less, the restricted model is taken for granted therefore the compliance of the factorial invariance. The difference of the CFIs obtained allows accepting the metrical invariance model. We can conclude up to this point that factorial charges are equivalent in the two subsamples.

Table 4. *Goodness of fit indexes of each of the models tested in the factorial invariance.*

Model	Fit Indexes						
	$\chi 2$	gl	GFI	NFI	CFI	RMSEA	AIC
Model without restrictions	314.308	80	.973	.974	.981	.038	418.308
Metric Invariance	326.231	89	.972	.974	.981	.036	412.231
Strong factor invariance	339.563	92	.970	.972	.980	.036	419.563

Note: * p < .05; GFI = goodness of fit index; NFI = normed fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation; AIC = Akaike information criterion.

Having demonstrated the metric invariance between the subsamples, we evaluate the equivalence between intercepts (strong factorial invariance). The Indexes (Table 4) show a good adjustment of this model, evaluated independent as well as analyzed toward nesting with the metric invariance model. The difference between the two comparative indices of Bentler is .001; and the general adjustment index is .970 and the root mean square error of approximation is .036. Accepted then the strong invariance, the two evaluated models are equivalent toward the factorial coefficients and the intercepts.

The factors obtained in the confirmatory factor analysis, mostly all reached values above .75 of internal consistency in both samples; demonstrating adequate internal consistency for these type of subscales, particularly if it is considered the small number of items (Table 5).

Table 5. *Coefficient omega and alpha for the factors obtained in exploratory factor analysis subsamples 1 and 2.*

	Subsample 1		Subsample 2	
Factor	Ω	α	Ω	α
problem solving	.896	.896	.893	.851
scientific communication	.769	.888	.737	.818

4. Discussion

The main objective of the study was to investigate whether or not the psychometric results proposed by [1] are replicate for the Self-efficacy Problem Solving and Communication Scale through a sample of university students using a confirmatory factor analysis (CFA). The confirmatory factor analysis conducted in each subsample separately, supports the factorial structure of two factors: problem solving and scientific communication obtained by Aguirre et al. [1] that demonstrates an adequate internal consistency, particularly considering the small number of items in each; at the same time that the factors obtained present in general suitable standardized factor saturations, which correspond to those found in the study of [1]. Suggesting also the existence of strong evidence of cross-validation of the measure and therefore the stability of the structure until the contrary is proved.

5. Conclusion

The analysis of the psychometric properties of the Self-efficacy Problem Solving and Communication Scale, have shown, in this study as in the performed by Aguirre et al. [1], that a two-factor structure is viable and appropriate in accordance with established psychometric requirements when informants are the students themselves. The structure of two factors, based on statistical and substantive criteria, has shown adequate indicators of adjustment, reliability and validity. However, the scope of these results is limited, and it is necessary further research to confirm the structure obtained, which will allow counting with more robust evidence regarding the factorial structure of the scale. Specifically, it must be demonstrated if the invariance of the structure of the scale is accomplished by gender, age, between students from different degrees, among others; so that, is considered that more studies are needed in order to confirm or refute the data obtained in investigations carried out so far.

It is also indispensable to check if the scale is useful to study the relationship between academic self-efficacy and learning.

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