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Examining reliability and validity of the Community of Inquiry survey (CoI)

Análisis de la fiabilidad y validez del cuestionario Comunidad de Indagación (CoI)

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ABSTRACT. Community of Inquiry is a theoretical framework with great influence in the investigation of online learning in Higher Education. This study examines the reliability and validity of a neutral Spanish version of the Community of Inquiry (CoI) Survey (v14) for online learning. The sample is composed of Spanish and Latin-American online university students. The results revealed a high reliability for the instrument (Conbrach's α = .978) and the different presences (Conbrach's α = .956 and higher). Three factor-structures of the CoI framework explained 71% of the variance in the pattern of relationships among the items using the first split-half sample. Confirmatory Factor Analysis (CFA) demonstrates a good fit to the data from the sample to the sub-scales «Teaching presence» and «Cognitive presence» but an adequate fit was not found for the sub-scale Social presence. It is suggested that some of the items of the instrument be revised to improve its construct validity.

RESUMEN. La Comunidad de Indagación es un marco teórico con gran influencia en la investigación del aprendizaje en línea en Educación Superior. Este estudio examina la fiabilidad y validez de una versión en español de la Encuesta de Comunidad de Indagación (v14). La muestra está compuesta por estudiantes universitarios online españoles y latinoamericanos. Los resultados revelan una alta fiabilidad del instrumento (α de Conbrach = .978) y de las diferentes presencias (α de Conbrach = .956 y superiores). Tres estructuras factoriales del cuestionario explicaron el 71% de la varianza en el patrón de relaciones entre los ítems. El análisis factorial confirmatorio (AFC) demuestra un buen ajuste de los datos de la muestra a las subescalas «Presencia docente» y «Presencia cognitiva», pero no se encontró un ajuste adecuado para la subescala Presencia social. Se sugiere revisar algunos de los ítems del instrumento para mejorar su validez de constructo.

KEYWORDS: Community of inquiry, Social presence, Teaching presence, Cognitive presence, Confirmatory factor analysis.

PALABRAS CLAVE: Comunidad de Indagación, Presencia social, Presencia de la enseñanza, Presencia cognitiva, Análisis factorial confirmatorio.

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1. Introduction

E-learning and b-learning are disruptive educational technologies which are transforming the conceptualisation of learning and teaching in the context of Higher Education (Christensen & Horn, 2008; Garrison, 2017). Pedagogic principles of an innovative online education are coincident with active and constructive learning but it possesses a differentiating quality: one must pay special attention to the development of a sense of community between participants in order to generate deep learning (Bishop et al., 2019).

Community of Inquiry (CoI) is a theoretical framework that provides the means to study and understand online collaborative learning in Higher Education. The investigation has demonstrated its capacity to predetermine, generate hypotheses and examine them empirically, making observations as well as providing explanations in the interpretation of results (Garrison, 2017). CoI framework was first proposed in an article by Garrison, Anderson and Archer (1999) and it has become the theoretical reference leading investigations about e-learning and b-learning (Author, 2020). A recent systematic revision of themes and tendencies within educational investigation within Higher Education, which adopted the CoI Framework, identified 23 studies made between 2009-2019 (Kim & Gurvitch, 2020). In its development, three independent but interrelated components are identified (Arbaugh et al., 2008; Garrison et al., 2010; Ke, 2010; Nagel & Kotzé, 2010): Social Presence (SP), Cognitive Presence (CP) and Teaching Presence (TP) (Figure 1).

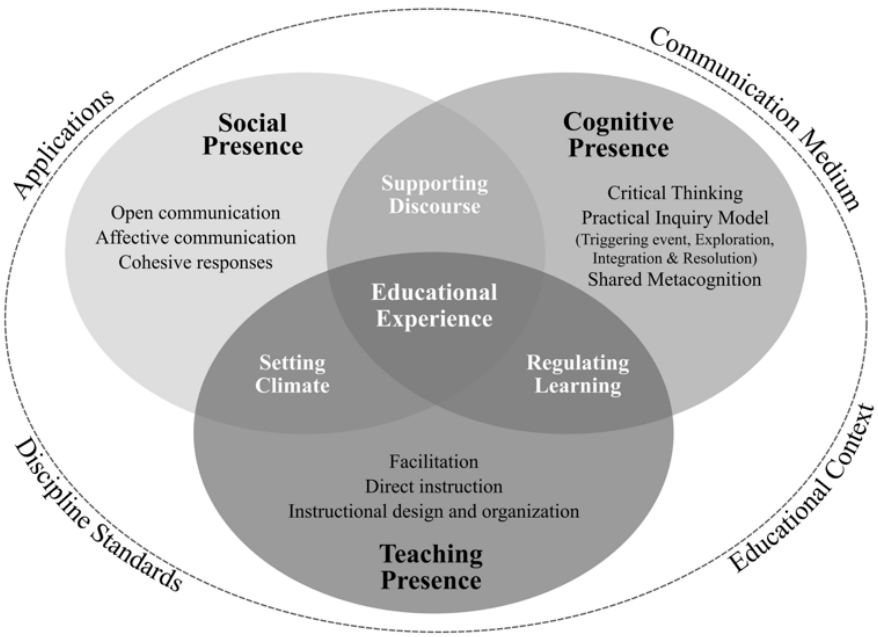

Figure 1. Community of Inquiry Framework. Source: Adapted from Garrison (2017, p. 25).

1.1. CoI Survey

The Community of Inquiry Framework survey instrument was developed by Arbaugh et al. (2008) and Swan et al. (2008) in order to provide quantitative guidance to CoI research. Stenbom (2018) conducted a systematic review of the literature on the CoI survey in the period 2008-2017 on a total of 103 research papers. The instrument has been translated into different languages: Arabic (Alaulamie, 2014), Turkish (Horzum & Uyanik, 2015), Korean (Yu & Richardson, 2015), Chinese (Ma et al., 2017), Portuguese (Moreira et al., 2013) and French (Heilporn & Lakhal, 2020). Multiple studies have been conducted on the reliability and validity of the CoI survey (Table 1).

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Reference	Analysis	Sample size Country Educational Level	Results
Arbaugh et al. (2008) Swan et al. (2008)	Internal reliability. Exploratory factor analysis.	N = 287 United States & Canada. Graduate-level courses in either Education or Business.	*Cronbach's Alpha* TP (Teaching Presence): .94 SP (Social Presence): .91 CP (Cognitive Presence): .95 AFE (Analysis factorial exploratory) supports the construct validity of TP, SP and CP as measured by the CoI.
Bangert (2009)	Internal reliability. Exploratory factor analysis & Confirmatory factor analysis.	N = 1173 United States. Undergraduate and graduate students.	*Cronbach's Alpha* TP: .96 SP: .91 CP: .95 AFE supports the construct validity of TP, SP and CP as measured by the CoI, except item 28 with crossload on both the CP (.424) and SP (.453) factors. CFA (Confirmatory factor analysis) found that the hypothesized three-factor model for the CoI Survey yielded RMSEA=.069, indicative of a «reasonable» fit.
Shea & Bidjerano (2009)	Internal reliability. Exploratory factor analysis & Confirmatory factor analysis.	N = 2159 United States. Freshman, sophomore, junior, senior, and graduate students online of 30 public state universities.	*Cronbach's Alpha* TP: .96 SP: .92 CP: .95 AFE confirms the construct validity of TP, SP and CP as measured by the CoI. CFA offered adjustment indices (CFI, GFI) indicative of a «good» fit.
Díaz et al. (2010)	Internal reliability. Exploratory factor analysis.	N = 412 United States. Graduate and undergraduate students at four colleges and universities.	*Cronbach's Alpha* TP: .96 SP: .92 CP: .95 PCA supports the construct validity of TP, SP and CP as formulated in the CoI model. Students believed TP to be more important than both CP and SP.
Carlon et al. (2012)	Internal reliability. Exploratory factor analysis.	N = 330 United States. 38 online courses in the College for Health Professions graduate and undergraduate programs of nursing, physical therapy and health care administration (including health information management students).	*Cronbach's Alpha* TP: .963 SP: .911 CP: .938 EFA confirmed the factor structure of the original CoI study model. Social Presence yielded two factors reflected as «Social Experience» and «Social Comfort».
Kozan & Richardson (2014)	Internal reliability. Exploratory factor analysis & Confirmatory factor analysis.	N = 643 United States. Graduate students pursuing a fully online Learning, Design, and Technology Master of Science Program in a College of Education.	*Cronbach's Alpha* TP: .966 SP: .944 CP: .927 EFA identificó tres factores que coinciden completamente con el CoI framework. CFA offered adjustment indices (NNFI, and GFI) indicative of a «very good» fit.
(Yu & Richardson, 2015)	Internal reliability. Exploratory factor analysis & Confirmatory factor analysis.	N = 995 Korea. Undergraduate students of a Cyber University.	*Cronbach's Alpha* TP: .954 SP: .913 CP: .956 The validity of the CoI instrument in Korean was demonstrated with the three-factor structure defined by the CoI model.
Caskurlu (2018)	Internal reliability. Confirmatory factor analysis.	N = 310 United States. 12 fully online graduate level courses offered in a Learning Design and Technology program at a large University.	*Cronbach's Alpha* TP: .96 SP: .96 CP: .89 CFA of the TP, SP and CP demonstrated a clear three-factor (TP & SP) and four-factor (CP) solution as proposed by the CoI framework.
Olpak & Kiliç Çakmak (2018)	Internal reliability. Exploratory factor analysis & Confirmatory factor analysis.	N = 1150 Turkey. Students enrolled in online courses in various departments in three Turkish state universities	*Cronbach's Alpha* TP: .965 SP: .953 CP: .972 EFA and CFA results for the adaptation to Turkish of the CoI survey showed the adequacy of the model to the sample data at an acceptable level.
Ballesteros Velázquez et al. (2019)	Internal reliability. Exploratory factor analysis	N = 162 Spain. Degree and Master students of the Faculties of Education, Law and Philosophy, belonging to the National University of Distance Learning (UNED).	*Cronbach's Alpha* TP: .921 SP: .926 CP: .938 AFE permits the identification of TP, SP and CP, in agreement with the theoretical foundation put forth by the instrument.
Heilporn & Lakhal (2020)	Internal reliability. Exploratory factor analysis & Confirmatory factor analysis.	N = 763 Canada. French-speaking students enrolled in online courses at one medium and one large size universities in Quebec, Canada.	*Cronbach's Alpha* TP: .95 SP: .93 CP: .95 Good fitting models were obtained for a CoI structure in ten categories.

Table 1. Previous studies regarding reliability and validity. Source: Self-made.

The purposes of this study are: (a) to estimate the reliability of the CoI Survey for the neutral Spanish version and verify the three subscale structure of the 34 items comprising the instrument; (b) confirm that the data for Teaching presence conforms to (fits) the established three-factor model of the CoI Framework; (c) confirm that the data for Social presence conforms to (fits) the established three-factor model of the CoI Framework and (d) confirm that the data for Cognitive presence conforms to (fits) the established four-factor model of the CoI Framework.

2. Methodology

2.1. Participants

The sample of this study consists of online university students pursuing undergraduate or postgraduate studies at public and private universities in Spain and Latin America (N=433). Participant demographic characteristics are detailed in Table 2.

	n	Percent
Gender		
Male	126	29.1%
Female	307	70.9%
Age		
18-26	118	27.3%
27-40	199	46%
41 and older	116	26.8%
Knowledge area		
Art and Humanities	122	28.2%
Sciences	45	10.4%
Health Sciences	43	9.9%
Social and Legal Sciences	179	41.3%
Engineering and Architecture	44	10.2%
Educational Level		
Degree	209	48.3%
Post-Graduate	224	51.7%
Previous hours of online training		
Up to 60 hours	114	26.3%
Between 61-545 hours	211	48.7%
More than 545 hours	108	24.9%
Nationality / Region		
Spain	338	78.1%
South America (Argentina, Columbia, Bolivia, Ecuador and Peru)	82	18.9%
Central America and The Carribean (Honduras, The Dominican Republic and Panama)	13	3%

Table 2. Demographic characteristics of online university students. Source: Self-made.

2.2. Measure

A neutral Spanish translation of the CoI instrument was used (Arbaugh et al., 2008; Swan et al., 2008) which was linguistically validated by two expert philologists. For the Spanish version (https://bit.ly/coispa), v14 was used, which is published on the CoI Framework website as open source and under Creative Commons license. The questionnaire is composed of 34 items which measure Teaching Presence, Social Presence and Cognitive Presence.

2.3. Data analysis

The total sample (n = 433) was randomly divided into two split-half samples by using the SPSS version 25. Exploratory factor analysis (EFA) was performed on the first split-half samples (n = 217) and confirmatory factor analysis (CFA) was performed on the second split-half samples (n = 216).

The exploratory factor analysis was conducted by using principal components analysis (PCA) with SPSS v.25. In this study, the three factors of social, cognitive, teaching presences were used to determine the pattern of structure in the 34 item measurement of the CoI framework. Exploratory factor analysis (EFA) does not require a priori to establish the structure of the data. However, in our case we start from a theory that underpins the instrument, so the EFA allows us to empirically confirm its conceptual structure and determine the function of each item in the overall set of the questionnaire (survey). We are referring to the total variance explained by the factors, the variance explained by each factor and the saturation of the items in the factors. Confirmatory factor analysis (CFA) was performed by applying a Structural Equation Model (SEM) using AMOS v24. Its objective is to examine the CoI Framework by specifying a model, for each of the three presences, that represents predictions of the theory between plausible constructs measured with the appropriate observed variables, i.e. the Items of the CoI instrument for each dimension and sub dimension.

The quality of the SEM results depends on the validity of the theory analyzed (Kline, 2016).

EFA and CFA both have the same objective: «to explain the covariances or correlations between many observed variables by means of relatively few latent variables» (Bollen, 1989, p.226). However, CFA has some advantages over EFA. First, CFA separates from the variance of each item of the CoI instrument, the part of the variance explained by the factor and the part not explained by the factor. It then differentiates the two variables and calculates their coefficients and variances separately. Consequently, once the error is identified, it only acts with the punctuation portion of the item that is considered to represent the latent variable. Furthermore, the theoretical space that CFA enables in the interpretation of error is very flexible, either because of the specific characteristics of the questionnaire or because of the nature of the concept. Finally, CFA offers the possibility of establishing relationships between factors, because more flexible conditions are allowed than in EFA (Herrero, 2010).

3. Results

3.1. Descriptive statistics

Ordinal responses were scored using the scale (1 = Strongly Disagree) to (5 = Strongly Agree). The average among answers in the 34 items ranges from the lowest: 3.55 in item 15 («I was able to form distinct impressions of some course participants»), to the highest: 4.71 in item 4 («The instructor clearly communicated important due dates/time frames for learning activities»). The highest typical deviations are seen in item 14 («Getting to know other course participants gave me a sense of belonging in the course») with SD = 1.34 and the lowest in item 4 («The instructor clearly communicated important due dates/time frames for learning activities») with SD = .64. Considering the items of the Teaching Presence together (items 1-13) obtain an average of 3.91 (SD = .90). In the case of Social Presence (items 14-22), the average is 3.75 (SD = .98). For Cognitive Presence (items 23-34), the average is 3.97 (SD = .81).

3.2. Item analysis for reliability

For the examination of the internal reliability of the instrument as a whole and of each of the subscales, Cronbach's α was calculated. The sample earned a reliability of .978 for the CoI survey. Reliability in the subscales teaching presence, social presence and cognitive presence were .961, .949 and .956, respectively, showing a high internal consistency between items. The T-test of Hotelling is p <.000 so we reject the H0 and observe that there are statistically significant differences between the security values of the items on the scale. Notwithstanding, as Taber argues (2018, p.1289): «it is at least as important that such scales measure what they claim to measure (that is, that they are valid) as that they can be shown to be unidimensional—so construct validity also needs to be demonstrated». For this reason we use EFA and CFA for the validity study of the instrument construct (Table 3).

	Mean	Std. deviation	Skewness	Kurtosis	Min	Max	N
Teaching presence	3.91	.904	-.570	-.368	1	5	217
Social presence	3.75	.908	-.611	-.088	1	5	217
Cognitive presence	3.97	.814	-.817	.806	1	5	217

Table 3. Descriptive statistics of each element of the Community of Inquiry (CoI). Source: Self-made.

3.3. Exploratory factorial analysis (EFA) for validity

The KMO value is .957, very close to the unit, which proves that the data possesses an excellent fit to a factor analysis model. KMO values above 0.9 are superb (Field, 2009). The contrast of Barlett indicates that the null hypothesis is significant and therefore it makes sense to apply factor analysis to this scale. The scree plot shows us that only the eigenvalues of the first three variables are greater than 1, so these three variables will be the main components that will summarize the rest, representing them coherently (Table 4 and Figure 2).

Components	Items	Dimensions
Factor 1	14-22 and 28	Social Presence
Factor 2	1-13	Teaching Presence
Factor 3	23-27 and 29-34	Cognitive Presence

Table 4. Components, items and dimensions. Source: Self-made.

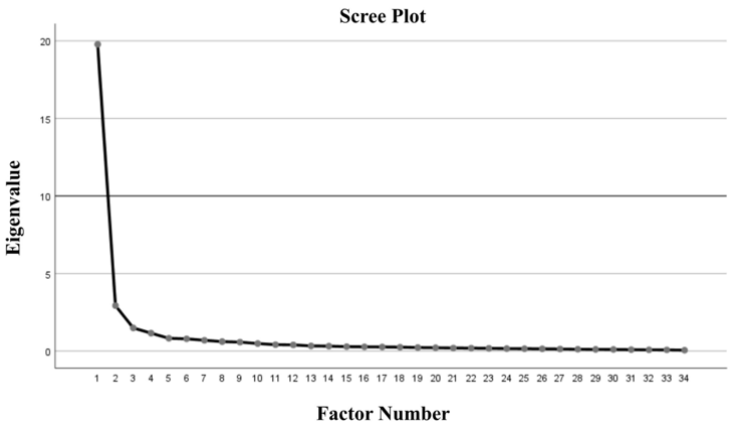

Figure 2. Scree plot for the Spanish version of the Community of Inquiry (CoI) instrument. Source: Self-made.

These three factors accounted for approximately 71% of the total item variance. The first factor extracted captured all the items from the Social Presence subscale and item 28 is added («Discussing course content with my classmates was valuable in helping me appreciate different perspectives»). This factor accounted for 58.1% of the total variance. All items assessing Teaching Presence (1-13) loaded on the factor 2 accounting for 8.60% of the variance. The third factor accounted for 4.37% of the variance and captured all 12 Cognitive Presence items (Table 5).

N.º	Items	Component		
		1	2	3
SP19	I felt comfortable interacting with other course participants.	.884		
SP20	I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.	.840		
SP18	I felt comfortable participating in the course discussions.	.819		
SP21	I felt that my point of view was acknowledged by other course participants.	.815		
SP22	Online discussions help me to develop a sense of collaboration.	.758		
SP15	I was able to form distinct impressions of some course participants.	.754		
SP17	I felt comfortable conversing through the online medium.	.741		
SP14	Getting to know other course participants gave me a sense of belonging in the course.	.732		
CP28	Discussing course content with my classmates was valuable in helping me appreciate different perspectives.	.689		
SP16	Online or web-based communication is an excellent medium for social interaction.	.669		
TP6	The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.		.785	
TP3	The instructor provided clear instructions on how to participate in course learning activities.		.777	
TP1	The instructor clearly communicated important course topics.		.756	
TP2	The instructor clearly communicated important course goals.		.742	
TP8	The instructor helped keep the course participants on task in a way that helped me to learn.		.742	
TP5	The instructor was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn.		.740	
TP7	The instructor helped to keep course participants engaged and participating in productive dialogue.		.709	
TP13	The instructor provided feedback in a timely manner.		.642	
TP9	The instructor encouraged course participants to explore new concepts in this course.		.641	
TP12	The instructor provided feedback that helped me understand my strengths and weaknesses.		.639	
TP11	The instructor helped to focus discussion on relevant issues in a way that helped me to learn.		.608	
TP10	Instructor actions reinforced the development of a sense of community among course participants.		.608	
TP4	The instructor clearly communicated important due dates/time frames for learning activities.		.418	
CP34	I can apply the knowledge created in this course to my work or other non-class related activities.			.831
CP33	I have developed solutions to course problems that can be applied in practice.			.761
CP27	Brainstorming and finding relevant information helped me resolve content related questions.			.736
CP24	Course activities piqued my curiosity.			.711
CP32	I can describe ways to test and apply the knowledge created in this course.			.698
CP25	I felt motivated to explore content related questions.			.695
CP26	I utilized a variety of information sources to explore problems posed in this course.			.604
CP30	Learning activities helped me construct explanations/solutions.			.590
CP29	Combining new information helped me answer questions raised in course activities.			.588
CP23	Problems posed increased my interest in course issues.			.569
CP31	Reflection on course content and discussions helped me understand fundamental concepts in this class.			.541

Table 5. Factor pattern matrix. Source: Self-made.

3.4. Confirmatory factor analysis (CFA) for predictive validity

3.4.1. Modelo «Teaching presence»

Model TP(1)

This model is based on the theoretic proposal of Garrison (2017b) which argues that three factors exist to integrate the component «Design Organization»: «Exploration», «Facilitation» and «Direct Instruction». The CFI values of .920 and RMSEA of .129 are indicative of an extremely poor fit of the model to the data. Therefore, it is clear that some modification is needed in the specification to identify a model that better represents the sample data. To identify possible areas of mismatch, the modification indexes (MI) were examined. These indexes provide more direct guidance for parameters that may be poorly specified. They show the extent to which the hypothetical model is properly described. MI values less than 10.00 are considered of low value since their consideration will not result in any significant change in the overall fit of the model (Byrne, 2016) (Figure 3).

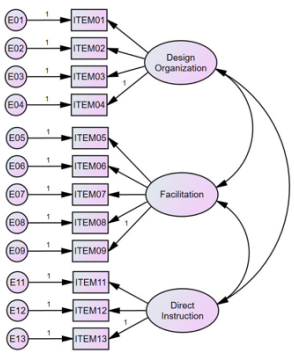

Figure 3. Model 1 of the Teaching presence TP(1). Source: Self-made.

Looking at covariance-related IMs, a clear misspecification linked to the pairing of error terms associated with item 11 and «Direct Instruction» factors (MI - 55,375) and «Facilitation» (MI - 53,560) are evident. Estimating these parameters in subsequent analyses suggests that it would decrease the chi-squared value and there would be a substantial difference in model fit. These covariances represent a systematic measurement error in the responses to item 11 and can derive from specific characteristics of the item or sample (Aish & Jöreskog, 1990). In this case it may be due to a high degree of overlap in the content of item 11 with the two factors involved and could mean that item 11, in addition to measuring «Direct Instruction», also measures «Facilitation». If we examine the contents of the item you can check that it concludes with the expression «... that helped me learn,» adding a meaning of «support» to the student by the teacher. The review of factor loads (regression weights) shows two parameters indicative of cross-loads (item 11 ← item 07; item 11 ← item 09) with MI values of 36,548 and 37,379, respectively. This reflects a problematic link between items 7 and 9 with item 11, which we will address by specifying error covariance (Byrne, 2016).

Model TP(2)

The re-specification of the model, starting with MIs, includes correlated errors (E07 ↔ E11; E09 ↔ E11) and the load of item 11 in the «Facilitation» factor. As a result, there is a decrease in the chi-squared value ($\Delta\chi2(1) = 118.822$) and an obvious improvement, compared to Model 1, both in the RMSEA (.129 vs .078) and in the CFI (.920 vs .971) (Figure 4).

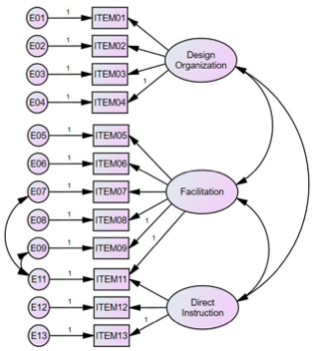

Figure 4. Model 2 of the Teaching presence TP(2). Source: Self-made.

Examining the MI results in Model 2 it is seen that the error covariance related to items 5 and 8 (MI = 22.205), as well as between items 5 and 6 (MI x 16.007), remains a parameter misspecified in the model. Content redundancy appears to exist between these questionnaire items. Between item 5 and 8, active participation of teachers is common to encourage learning, through support on content and activities. It is also noted that item 5 and 6 share very similar content linked to the teacher's action to facilitate understanding. Consequently, the need to include these covariances in the model is estimated.

Model TP(3)

Goodness-of-fit statistics related to Model 3 again show a statistically significant improvement over Model 2 ($\Delta\chi2(2) = 38.991$), as well as substantial differences in RMSEA (.052 vs .078) and CFI (.988 vs. .971) values. When we examine the MI, we see that a single error covariance (E01 ↔ E07) is presented with a value of 11.924, which is considered very weak, being very close to the value 10 and, consequently, it is considered that its incorporation into the model should not be considered (Figure 5).

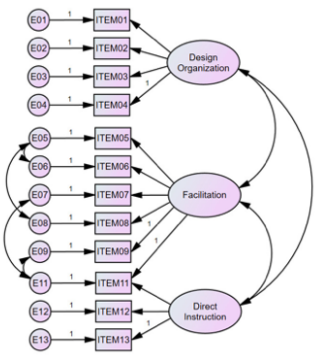

Figure 5. Model 3 of the Teaching presence TP(3). Source: Self-made.

Since kurtosis can affect variance and covariance tests (DeCarlo, 1997) evidence of multivariate kurtosis is needed to be analyzed, as it has been observed to have detrimental effects on SEM (Byrne, 2016). West et al. (1995) consider that values equal to or greater than 7 are indicative of kurtosis distribution. Model data shows that no items are substantially kurtotic. Positive values range from .034 to 4.826 and negative values -.256 to -.350, implying an overall average univariate kurtosis value of 0.894. Moreover, Bentler (2006) suggests that standardized estimates > 5.00 are indicative of data that are distributed in a non-normal way. In our case, the z-statistic value (c.r.) of 39,538 reports on the multivariate non-normality of the sample (Table 6).

Measures of fit	Expected	Expected (Hu & Bentler, 1999)	Expected (Byrne, 2016)	Obtained
Chi-Square	> 0,05			.000
Discrepancy between Chi-Square and degrees of liberty (CMIN/DF)	< 5			1.592
Goodness-of-fit index (GFI)	0.90 - 1	>0.90	Values approaching 1	0.945
Adjusted goodness-of-fit index (AGFI)	0.90 - 1		Values approaching 1	0.908
Standardized Root Mean Squared Residual (SRMR)	Closest to 0	Close to 0.09	< 0.05	0.0263
Root mean square error of approximation (RMSEA)	< 0.05 / 0.08		<0.05 /0.08	0.052
Comparative fit index (CFI)	0.90 - 1	>0.95	>0.95	0.988
Normed fit index (NFI)	0.90 - 1	>0.95	>0.95	0.968
Non-normed fit index or Tucker-Lewis index (NNFI o TLI)	0.90 - 1	>0.95		0.983

Table 6. Expected measures of fit for a model of structural equations and indices obtained for the confirmatory factor analysis of the model «Teaching Presence». Source: Self-made.

Mulaik y col. (1989) suggest that non-significant $\chi 2$ statistics, as in our case, and goodness-of-fit indices around .90, accompanied by parsimonious adjustment rates around .50, are not unexpected. Therefore, the value obtained from PGFI of .569 appears to be consistent with the previous adjustment statistics. Our IFC (.988) indicates that the model fits well with the data, i.e. the hypothetical model adequately describes the sample data. Moreover, the NFI (0.968) suggests that the fit of the model is also adequate. Similar to the NFI calculation, the IFI consistently offers similar values, or equal values, as in our case, to the IFC (0.988) indicating a good fit to the model. Finally, the TLI values close to .95 are indicative of a good fit (0.983). RMSEA is recognized as one of the most informative criteria in the modeling of covariance structures (Byrne, 2016). The RMSEA value for our hypothetical model is .052, which is a good fit, with a 90% confidence interval, ranging from .028 to .074 and the p-value for the fit closeness test is equal to .000. The interpretation of the confidence interval indicates that we can be 90% sure that the true RMSEA value in the population will be within the limits of .028 and .074, which represents a good degree of accuracy.

Taking into account (a) the feasibility and statistical significance of all parameter estimates; (b) the good fit of the model, as evidenced in particular by the values of IFC (0.988) and RMSEA (0.052) and (c) the lack of relevant evidence concerning poor adequacy of the model, it is concluded that Model 3 (Figure 5), represents an appropriate description of the structure of the «Teaching Presence» component of the Community of Inquiry (CoI).

3.4.2. Model «Cognitive presence»

Model CP(1)

This model is based on the theoretical proposition of Garrison (2017b) which argues that four factors exist to integrate this component: «Triggering event», «Exploration», «Integration» and «Resolution» (Figure 6).

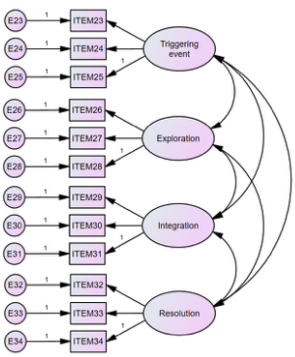

Figure 6. Model 1 of the Cognitive presence CP(1). Source: Self-made.

With a CFI value of .943 and an RMSEA of .110, it is evident that this model has a very poor fit to the sample data. Therefore, some transformation must be performed to recognize a model with a better representation of the data. As such, we analyzed the modification indexes (MI) to identify where possible model 1 mismatches might be found.

In covariance-linked MIs, a misspecification related to the pairing of error terms associated with item 28 and the «Integration» factor (MI -35,325) is observed. Likewise, other error measurement covariance associated with items 28 and 29 (E28 ↔ E29; MI = 18,238) are identified; and between those associated with items 23 and 26 (E23 ↔ E26; MI 16,123). Estimating these parameters in a later model would lead to a reduction in the chi-squared value and a better fit. We consider that item 28 could be measuring the «Integration» factor in addition to the «Exploration» factor. The key can be found in the use of the term «understand different perspectives» which is compatible with the meaning attributed to items belonging to the «Integration» factor (29, 30 and 31), being oriented towards the «[development] of explanations or solutions» (item 30), «[understanding of] the fundamental concepts of the course» or «[answer] to the questions posed in the course activities». On the other hand, it is possible to identify some overlap of contents between items 28 and 29, which express a common idea about the relevance of the sharing of diversified information, for the understanding and solution of problems. Furthermore, between items 23 and 26 that share the expression «problems raised» and are similarly oriented towards curiosity and exploration.

Model CP(2)

Once the model re-specification is applied, from the MIs, correlated errors (E23 ↔ E26; E28 ↔ E29) are included; and the load of item 28 in the «Integration» factor. As a result, there is a reduction in the chi-squared value ($\Delta\chi2(1) = 57.445$) and an obvious improvement over model 1, both in the RMSEA (.110 vs . 083) and in the CFI (.943 vs . 969).

From the analysis of MIs obtained from model 2, it can be shown that the error covariance related to items 24 and 29 (MI = 14.921), appears as a parameter misspecified in the model. We interpret that both items share a meaning linked to the inquiry process in which the student actively seeks personal meaning and shared understanding (Garrison, 2017). Therefore, it is considered necessary to include these covariances in the model (Figure 7).

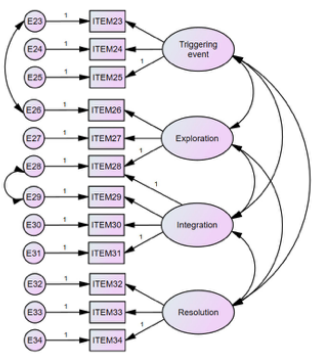

Figure 7. Model 2 of the Cognitive presence CP(2). Source: Self-made.

Model CP(3)

As expected, the goodness-of-fit indices related to Model 3 show a statistically significant decrease in addition to the chi-squared value, relative to model 2 ($\Delta\chi2(2) = 16.703$), as well as substantial differences in RMSEA (.083 vs. .074) and CFI values (0.969 vs. 0.976). Examination of the MIs allows us to identify an error covariance associated with item 29 and the «Exploration» factor. The MI value equalling 11.546, is considered insufficient for incorporation into the model. All other error covariances of the model are clearly

below the value 10. Examining kurtosis in the model data shows that the values range from .298 to 1.428, implying an overall average univariate kurtosis of .818. Considering that values equal to or greater than 7 would be indicators of a kurtotic distribution (West et al., 1995), it can be observed that no item is substantially kurtotic. On the other hand, the z-statistic value (c.r.) of 39.935 reports the multivariate non-normality of the sample (Table 7).

Measures of fit	Expected	Expected (Hu & Bentler, 1999)	Expected (Byrne, 2016)	Obtained
Chi-Square	> 0,05			.000
Discrepancy between Chi-Square and degrees of liberty (CMIN/DF)	< 5			2.176
Goodness-of-fit index (GFI)	0.90 - 1	>0.90	Values approaching 1	0.933
Adjusted goodness-of-fit index (AGFI)	0.90 - 1		Values approaching 1	0.883
Standardized Root Mean Squared Residual (SRMR)	Closest to 0	Close to 0.09	< 0.05	0.0289
Root mean square error of approximation (RMSEA)	< 0.05 / 0.08		<0.05 /0.08	0.074
Comparative fit index (CFI)	0.90 - 1	>0.95	>0.95	0.976
Normed fit index (NFI)	0.90 - 1	>0.95	>0.95	0.957
Non-normed fit index or Tucker-Lewis index (NNFI o TLI)	0.90 - 1	>0.95		0.965

Table 7. Expected measures of fit for a model of structural equations and indices obtained for the confirmatory factor analysis of the model «Cognitive Presence». Source: Self-made.

The PGFI value of .538 appears to be consistent with adjustment statistics (Mulaik et al., 1989). The CFI value (.976) indicates that the model fits well with the data, that is, that the hypothetical model adequately describes the sample data. Moreover, the NFI (0.957) suggests that the fit of the model is also adequate. Similar to the NFI calculation, the IFI consistently offers the same value as the CFI (.976) indicating a good fit to the model. Finally, the TLI values close to .95 are indicative of a good fit (0.965). The RMSEA value for our hypothetical model is .074, which is an acceptable fit, lying between values .05 and .08 (Figure 8).

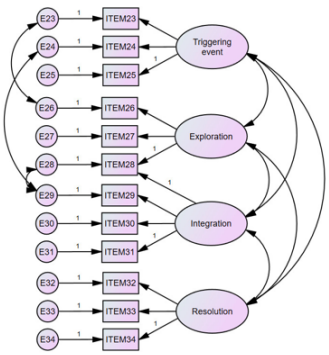

Figure 8. Model 3 of the Cognitive presence CP(3). Source: Self-made.

Taking into account (a) the statistical significance of all parameter estimates; (b) the good fit of the model, as evidenced in particular by the values of CFI (.976) and RMSEA (.074) and (c) the lack of relevant evidence on the lack of adequacy of the model, it is concluded that Model 3 (Figurere 8), represents an ideal description of the structure of the «Cognitive Presence» component of the Community of Inquiry (CoI).

3.4.3. Model «Social presence»

Model SP(1)

This model is based on Garrison's theoretical proposal (2017b) which holds that there are three factors that make up this component: «Affective Communication», «Open Communication» and «Group Cohesion»

(Figure 9).

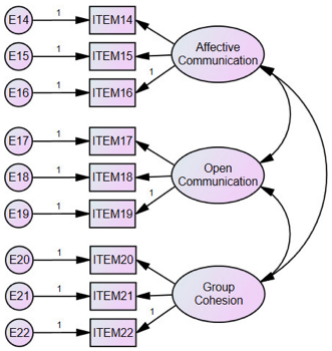

Figure 9. Model 1 of the Social presence SP(1). Source: Self-made.

The CFI values of .927 and RMSEA of .144 are indicative of a very poor fit of the model to the data. Therefore, modifications must be made to identify a model that better represents the sample data. In order to identify possible areas of mismatch, the modification rates (MI) were examined and it was seen that the error covariance related to items 16 and 17 (E16 ↔ E17; MI 33.292) and between items 14 and 17 (E14 ↔ E17; MI s 14.595) appears as an ill-specified parameter in the model. There seems to be a clear similarity of meanings in items 16 and 17, the former qualifies online communication as an «excellent means for social interaction» and in the second it certifies this quality through a feeling of «comfort» when using online communication. There are also similarities observed between items 14 and 17, in this case the perception of comfort in online communication is identified with a sense of belonging to the group. As a result, the need to reformulate the model from the analysis of MIs is appreciated, in order to obtain a better fit of the model to the sample data.

Modelo SP(2)

Once the model re-specification is applied, from MIs, correlated errors (E14 ↔ E17; E16 ↔ E17) are included. As a result, there is a reduction in the chi-squared value ($\Delta\chi2(1) = 38.82$) and an improvement, compared to Model 1, both in the RMSEA (.144 vs .122) and in the CFI (.927 vs .952) (Figure 10).

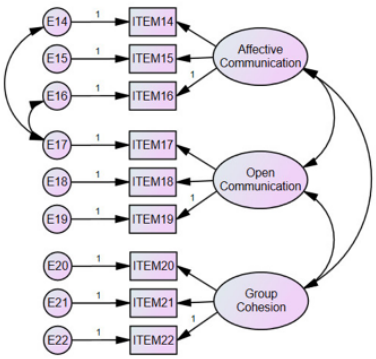

Figure 10. Model 2 of the Social presence SP(2). Source: Self-made.

Examination of MIs allows us to identify an error covariance associated with item 19 and item 20. It's MI value of 10.067, is considered insufficient for incorporation into the model. All other error covariances in the model are below the value 10. On the other hand, it is observed that no item is substantially Kurtotic. The z-statistic value (c.r.) of 28.271 indicates the multivariate non-normality of the sample (Table 8).

Measures of fit	Expected	Expected (Hu & Bentler, 1999)	Expected (Byrne, 2016)	Obtained
Chi-Square	> 0,05			.000
Discrepancy between Chi-Square and degrees of liberty (CMIN/DF)	< 5			4.204
Goodness-of-fit index (GFI)	0.90 - 1	>0.90	Values approaching 1	0.917
Adjusted goodness-of-fit index (AGFI)	0.90 - 1		Values approaching 1	0.829
Standardized Root Mean Squared Residual (SRMR)	Closest to 0	Close to 0.09	< 0.05	0.0498
Root mean square error of approximation (RMSEA)	< 0.05 / 0.08		<0.05 /0.08	0.122
Comparative fit index (CFI)	0.90 - 1	>0.95	>0.95	0.952
Normed fit index (NFI)	0.90 - 1	>0.95	>0.95	0.939
Non-normed fit index or Tucker-Lewis index (NNFI o TLI)	0.90 - 1	>0.95		0.922

Table 8. Expected measures of fit for a model of structural equations and indices obtained for the confirmatory factor analysis of the model «Social Presence». Source: Self-made.

Our IFC (.952) indicates that the model conforms to the data, i.e. the hypothetical model adequately describes the sample data. However, the NFI (0.939) suggests that the fit of the model is not fully adequate. Finally, the TLI (0.922) offers a value less than .95 as indicative of insufficient adjustment. The RMSEA value for our hypothetical model is .122, which is a poor fit, with a 90% confidence interval, ranging from .097 to .148 and the p-value for the fit closeness test is equal to .000. We can therefore say that it does not offer a good degree of precision.

Taking into account (a) the feasibility and statistical significance of all parameter estimates; (b) the poor fit of the model, as evidenced in particular by the RMSEA value (0.122) and (c) the relevant evidence on the lack of adequacy of the model, it is concluded that Model 2 (Figurere 10), does not represent an adequate description of the structure of the Community of Inquiry (CoI) component «Social Presence», although it is considered to be the best model for our data.

4. Discussion

The reliability indices (Conbrach's α) obtained in our sample on the Spanish version of the CoI Survey, in each of its subscales, are high and coincident with those reported by previous studies (Arbaugh et al., 2008; Ballesteros Velázquez et al., 2019; Bangert, 2009; Carlon et al., 2012; Caskurlu, 2018; Díaz et al., 2010; Heilporn & Lakhal, 2020; Kozan & Richardson, 2014; Olpak & Kiliç Çakmak, 2018; Shea & Bidjerano, 2009; Swan et al., 2008; Yu & Richardson, 2015) for Teaching presence (between .92 and .96), Social presence (between .97 and .91) and Cognitive presence (between .95 and .89).

The results confirm the three-factor structure of our Spanish version of the CoI Survey. The first factor extracted includes all the items in the Social presence subscale and adds item 28 of the Cognitive presence subscale («Discussing course content with my classmates was valuable in helping me appreciate different perspectives»). This result is similar to that reported by Bangert (2009) who found that item 28 had a cross load on both the Cognitive presence (.424) and Social presence (.453) factors. It raises the need to reformulate the wording of this item to correct its double meaning as an observed variable of social presence, which derives from its connotation on the value of social debate and, simultaneously, as an observed variable of cognitive presence, associated with the idea that the student acquires the understanding of different perspectives on a subject. Since item 28 is theoretically associated with cognitive presence, the communicative strategy (debate) could be overlooked and the wording focused on content directly linked to the «integration» phase of Practical Inquiry (PI), such as the incorporation of different approaches to the conceptual structure of the online student. The second factor obtained incorporates all the items of the Teaching presence subscale (1-13) and the third factor includes the set of items of the Cognitive presence subscale (23-27 and 29-34), with the exception of item 28 mentioned above.

CFA applied on the Teaching presence and Cognitive presence subscales has led to the obtaining of two models that show a good fit to the data of the study, coinciding with the results of previous (Bangert, 2009; Kozan & Richardson, 2014; Olpak & Kiliç Çakmak, 2018; Shea & Bidjerano, 2009; Yu & Richardson, 2015). In both cases the theoretical model of the CoI Framework has had to be revised, which informs us about the possibility of establishing some improvements in the items of each of these subscales. In particular, for the Teaching presence subscale we see the need to improve the wording of some items of the «Facilitation» dimension (items 5, 6, 7, 8 and 9) because of an apparent similarity in their contents, which could hinder discrimination between the theoretical observable variables defined in the CoI Framework. In addition, it should be analyzed whether item 11 offers a meaning of «Facilitation» in addition to «Direct Instruction», where it is included. Whatsmore, for the Cognitive presence subscale a need arises to improve the writing of some items to achieve a more specific meaning in relation to the category to which each of them belong: Triggering event (items 23 and 24), Exploration (items 26 and 28) and Integration (item 29).

On the other hand, the sample data from this study has not fit well with the CoI Survey's Social presence subscale model. While some adjustment indices (GFI, CFI) offer acceptable values, others (AGFI, NFI, TLI, and especially RMSEA) do not offer values that fall within the expected parameters for good model fit to the data. «Social Presence» has been the subject of discussion in the CoI literature and there is still no agreement among researchers on its conceptualization and its factor structure in CoIQ (Caskurlu, 2018). Although it is the most widely used construct to describe and understand how social interaction occurs in online learning contexts, its definition is not unanimous and lends itself to different interpretations (Lowenthal, 2010; Lowenthal & Dunlap, 2014). Our results also lead to the need to review the items that make up the Social Presence subscale to improve the validity of the instrument's construct. An in-depth analysis of the subscale items is required to assess their membership in each of these theoretical categories and the current representation of each of the categories in the CoI Survey. We believe that this could decrease the error covariance detected in CFA with some items. In our study specifically, this is the case with items 14, 16 and 17 of the subscale, in coincidence with the results obtained by Lowenthal & Dunlap (2014). We agree with Caskurlu (2018) regarding the possibility that Social Presence is a multidimensional construct which measures various concepts.

5. Conclusions

This study offers a Spanish version of the CoI Survey with a high level of reliability and confirmation of its validity of construct in relation to the CoI Framework. However, it is possible to apply some improvements to the instrument, especially in the Social Presence subscale, which has not shown sufficient fit to the theoretical model from the data in our sample. Given the relevance in the field of research on online learning in Higher Education of the CoI Framework, we consider that this study can contribute to its knowledge and development, especially in the context of spanish speakers, where the growth of online university training and, consequently, educational research on e-learning and b-learning is very important. We believe that the pedagogical principles that underpin the CoI Framework are best suited for the design and development of online courses that want to encourage deep learning. This research has some limitations that need to be considered. First, it is a translation into another language of the instrument with the difficulties of obtaining maximum fidelity to the purposes of its creators. Furthermore, although similar results have been identified with studies conducted on the CoI Survey in English, the wording of some items may incorporate subtle meanings that bring about some differences with the original. Finally, it should be considered that the online training context of Spanish speaking students in our study may show some differences with the educational field of most of the research previously carried out and may have had some influence on responses to the CoI Survey. For future lines of research it would be desirable to conduct comparative studies on the CoI Framework in different educational-cultural contexts, develop a new version of the instrument based on the evidence obtained over the past two decades and assess the CoI Framework's ability to design and develop online university training.

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