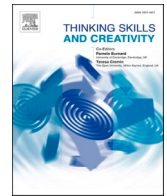




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Development of an instrument to assess young people's attitudes toward critical thinking

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ABSTRACT

A comprehensive current educational innovation aims to teach 21st-century skills, which invariably include critical thinking (CT). The implementation of CT requires some mastery of its constituent abilities and also holding the dispositions and attitudes that are necessary for its adequate enactment. The literature on CT attitude measurement uses one main measurement tool, which is very long and only applicable to adults. In order to include young people in this study, a new short and viable tool was designed to assess CT attitudes and analyze its psychometric properties. The design was carried out through a two-stage process that involved convenience samples made up of primary and secondary students from twenty different schools, who answered the developing instruments and whose data are analyzed through a polychoric correlation model. Confirmatory factor analysis reported optimal goodness-of-fit indexes for a six-factor structure of the instrument: confidence on reasoning, truth-seeking, open-mindedness, curiosity, system and prudence-analysis. The matrices of standardized coefficients and correlations between constructs provide evidence of convergent and discriminant validity for the six-factor model, which also attained good reliability indices. These psychometric results provide empirical support to the validity and reliability of the instrument's six-factor theoretical model, which allows the evaluation of young students' CT attitudes. Finally, the instrument's role in facilitating the educational interventions to foster CT learning from the educational elementary stages and the development of future research is discussed.

1. Introduction

The literature on critical thinking (CT) is very extensive, but there is no consensus on its definition or the skills that form CT¹. However, it is widely recognized that the exercise of CT requires a combination of skill mastery (cognitive skills whose competent use

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¹ Abbreviations: Critical Thinking (CT), Dispositions-Attitudes towards Critical Thinking (DACT), California Critical Thinking Disposition Inventory (CCTDI), Critical Thinking Disposition Assessment (CTDA), Confirmatory Factor Analyses (CFA), Questionnaire of Attitudes towards Critical Thinking (QATCT), Robust Unweighted Least Squares (RULS), Expected A Posteriori (EAP)

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Table 1

Summary of dispositions proposed in the literature, classified according to the seven dimensions of the California Critical Thinking Disposition Inventory (CCTDI).

Authors	Seven dimensions of the dispositions of the CCTDI							Others
	Truth-seeking	Open-mindedness	Analyticity	Systematicity	Self-Confidence	Inquisitiveness	Cognitive Maturity	
Delphi Facione (1990)	Being informed	Open-mindedness Others' Opinions	Review your own opinions	Alert to use CT Consider alternatives	Confidence in reasoning Self-confidence in reasoning	Curiosity about topics	Impartiality Facing one's own biases Suspending judgment	
Ennis (2015)	Seeking and offering clarity Being informed Precision-seeking Truth-seeking	Addressing the global situation Considering others' opinions	Alert to alternatives Finding and offering reasons	Offering clear reasons and relationships between questions and conclusion	Trying to get it right Employing CT skills and dispositions		Suspending judgment Taking and changing a reasoned position Awareness of beliefs	Affections and understanding of others Well-being of others
Paul and Elder (2008)	Using intellectual tools	Humility Courtesy Empathy Considering others	Recognizing the complexity Not thinking simply	Striving to improve Diligence Practice rationally all one's life	Trusting reason Thinking is flawed		Integrity Sense of justice Decrease biases	Making society more rational and civilized
Perkins et al. (1993)	Clarifying and seeking comprehension	Broad Adventurer	Finding and evaluating reasons	Planned and strategic	Meta-cognitive	Intellectual curiosity	Intellectually careful	
Halonen (1995)	Provisionality	Appreciating individual differences			Tolerance of ambiguity		Skepticism Respect for ethical practices	
Ferrett (1997)	Asking questions Finding evidence Adjusting to new facts	Admitting missing information Listening to others	Criteria for analyzing Finding solutions Examining in detail	Evaluating arguments Contrasting ideas versus facts	Accepting self- assessment	Curiosity	Suspending judgment Rejecting incorrect information Avoiding bias	
Halpern (1998)	Abandoning non- productive strategies Self-correction	Flexibility Open-mindedness		Regular use of plans			Participating and persevering Suppressing impulsivity	Awareness of social realities for actions
Petress, (2004)	Submitting your ideas and experiments for review	Imagining unexamined phenomena		Using the necessary time Anticipating consequences			Accepting challenges and criticisms	
Costa and Kallick (2008)	Clarity and precision when thinking and communicating Striving for precision	Listening with empathy Collecting data with all the senses Creating,	Questioning and raising issues Taking responsible risks	Thinking about thinking Thinking inter- connectedly	Thinking flexibly Applying to new situations	Responding with amazement and admiration	Persevering Managing impulsivity Continuous learning	Maintaining good humor

(continued on next page)

Table 1 (continued)

Fisher (2021)	Clarity of questions Precision	imagining, innovating	Focusing the issue	Order Diligence in searching for information	Reasonableness of criteria		Persistence despite difficulties
Manassero-Mas & Vázquez-Alonso, 2020	Researcher spirit Information-seeking Search for comprehension Proactivity Imagining or ideating	Open-mindedness and flexibility Accepting feedback Sharing and listening Empathy	Analytical in the search for reasons Exploration of alternatives	Reasoned change of opinion Systematization in the search for reasons Quality of reasoning Global view	Trust in the ability to reason Tolerance of uncertainty Thinking about one's own thinking Applying to new situations	Curiosity, surprise, admiration Undertaking Openness to risks, learning, perspectives	Free and independent Perseverance Sustained thinking Sense of responsibility Interest in ethical values Prevention of bias

Source: Author elaboration.

Truth-seeking: being eager to seek the best knowledge in a given context, courageous about asking questions, and honest and objective about pursuing inquiry even if the findings do not support one's self-interests or one's preconceived opinions.

Open-mindedness: being tolerant of divergent views and sensitive to the possibility of one's own bias.

Analyticity: prizing the application of reasoning and the use of evidence to resolve problems, anticipating potential conceptual or practical difficulties, and consistently being alert to the need to intervene.

Systematicity: being organized, orderly, focused, and diligent in inquiry.

Self-Confidence: the trust one places in one's own reasoning processes.

Inquisitiveness: one's intellectual curiosity and one's desire for learning even when the application of the knowledge is not readily apparent.

Maturity: disposition to be judicious in one's decision-making (Facione et al., 1996).

leads to thinking well) with adequate dispositions-attitudes towards CT (DACT) —trends that drive the use of the skills (APA, 1990; Manassero-Mas & Vázquez-Alonso, 2020; Ennis, 1996; Halpern, 1998; Paul & Elder, 2008).

To develop some consensus, the American Psychological Association (APA) organized a Delphi panel of experts that agreed on a definition of CT (APA, 1990; Facione, 1990), which Facione (1998) subsequently expanded, introducing dispositions, as the driving elements of the conceptual, methodological, and contextual awareness of the evidence that underpins judgment (affective dispositions).

CT education has now moved from higher education to other educational levels, reaching children and young people, for whom the tools for assessing the skills and existing dispositions are inadequate because they are designed for adults. This lack requires the creation of tests adapted to younger people, so the objective of this article is to develop an instrument for the evaluation of DACT in young people.

2. Profiles of critical thinkers and dispositions toward thinking

To alleviate the absence of consensus on the conceptualization of skills and DACT and center the topic, a CT theoretical framework is presented. The framework draws from two recently developed taxonomies, which organize both constructs in four dimensions. Authors (2019) proposed the dimensions of creativity, reasoning and argumentation, decision-making and problem-solving, and evaluation and judgment. On the other hand, Fisher (2021) proposes the dimensions of interpreting, analyzing, evaluating, and self-regulation.

The review of the main contributions of the literature on DACT is summarized in Table 1 due to space limitations. It is found that DACTs are multidimensional, but also that there are common characteristics (open-mindedness, intellectual curiosity, and reflective thinking) permeating many proposals. The pioneer definition of Glaser (1941) already proposed three components of CT (reflective attitudes, knowledge of logic, and skills for their application), and it is noteworthy that reflective attitudes constitute the first attitudinal component for the exercise of CT. Perkins et al. (1993) propose a model of three traits (inclinations, sensitivities, and abilities) that underlie DACTs.

The turning point on the affective aspects of CT was the Delphi report, which established a consensus (83%) among experts on the qualities of a good critical thinker, twelve of which are oriented to one's own life and the rest to specific problems of CT (APA, 1990; Facione, 1990). For all that, the most common CT dispositions are the seven dimensions proposed by Facione (1998), which are applied in Table 1 to summarize the literature on DACT.

Some literature suggests collaboration as an additional social thinking disposition due to the obvious dialogic function of CT in convincing or in discussing issues with others (Davies et al., 2018). Despite collaboration not being explicitly mentioned, multiple clues in this study highlight the many aspects of CT dispositions that point to social collaboration. For instance, the literature on open mindedness disposition (Table 1, second column) mentions the following collaborative aspects: considering others' opinions, listening with empathy, accepting feedback, sharing and listening, and understanding others. Again, the literature on others (Table 1, last column) mentions the following social aspects: well-being of others, making society more rational and civilized, and awareness of social realities for actions. All these dispositions display multiple elements that feature the collaborative traits of thinking.

In sum, the CT literature provides numerous and necessary DACTs to good thinking, which constitute a solid basis for considering that DACT delimits an important part of CT.

2.1. The evaluation of the dispositions toward critical thinking

There is less research on DACT measurement than on skill measurement. The field is dominated by the California Critical Thinking Dispositions Inventory (CCTDI), developed from the consensus statement of the Delphi study on the profile of the critical thinker (Facione & Facione, 1992; Facione et al., 2001) and other valuable contributions to DACT, such as the habits of mind and the thinking standards and virtues (Costa & Kallick, 2008; Ennis, 2015; Paul & Elder, 2008).

The CCTDI has 75 items grouped into seven dimensions or scales, whose names are Truth-Seeking (12 items), Self-Confidence (9), Systematicity (11), Analyticity (11), Cognitive Maturity (10), Inquisitiveness (10), and Open-Mindedness (12). For example, the item "Considering all the alternatives is a luxury I can't afford" displays an opposite attitude belonging to open-mindedness. The CCTDI is designed for use with the general adult population and requires respondents to mark their degree of agreement with the statements on a six-point Likert scale. Higher scores describe the most favorable DACTs.

Since its creation, the CCTDI has been the most applied instrument in the specialized literature to evaluate DACTs. Facione et al. (1995) obtained the highest scores in Open-mindedness and Inquisitiveness and the lowest in Systematicity and Truth-seeking. McBride et al. (2002) diagnosed positive dispositions in six scales and the total score of the CCTDI in physical education students in the United States. In contrast, nursing students in Hong Kong had mean negative dispositions, with high scores in Inquisitiveness and lower ones in Truth-seeking (Ip et al., 2000). In Turkey, Çubukcu (2006) diagnosed teacher candidates, finding that the most developed dispositions were Open-mindedness and Analyticity, and the least, Inquisitiveness and Systematicity.

International comparisons find differences between countries. Zoller et al. (2010) report differences between Israeli and American undergraduates and pre-university students, although both levels of education are similar in the two countries. Similarly, McBride et al. (2002) attributed the differences between practicing American and Chinese Physical Education teachers to the individualism-collectivism contrast of Western and Asian cultures. In the same vein, Yeh and Chen (2003) reported differences between American and Chinese nursing students on various scales (Truth-Seeking, Open-Mindedness, Systematicity, and Cognitive Maturity), and Tiwari et al. (2003) found that Australian nursing students presented a significantly better disposition than their Hong

Kong counterparts.

The CCTDI manual reports that the reliability values (Cronbach's alpha) referring to the initial pilot test for the seven scales are moderate (between 0.71 and 0.80) and that factor analysis supports the inclusion of the items in the scales. However, other CCTDI studies offer more diverse results; for example, lower alpha coefficients (between 0.59 and 0.75) in Chinese students (Zhang, 2003) and, in Taiwanese and North American students, Yeh (2002) reported alpha values between 0.34 and 0.73 and an overall alpha of 0.71 in the Chinese version, and values from 0.52 to 0.73 and an overall alpha of 0.71 in English. Escurra-Mayaute and Delgado-Vásquez (2008) report item-test correlations between 0.72 (Inquisitiveness) and 0.93 (Analyticity) and 0.96 for overall reliability, along with acceptable goodness-of-fit values for the confirmatory one-factor model of the total inventory.

Several studies have applied partial versions of the CCTDI. Wang et al. (2019) used 18 items and three CCTDI factors, reporting alpha values between 0.824 and 0.862 (factors) and 0.924 (global). Incikabi et al. (2013) used six dimensions and 51 items in practicing Turkish math teachers, obtaining a negative and weak correlation between dispositions and logical thinking skills. With the same instrument, Akgun and Uruk (2016) reported that the dispositions of future Turkish science teachers were low and did not show significant differences by sex, grade, or school.

The lack of effective instruments to diagnose DACT in professionals is an obstacle that has contributed to the development of alternative tests to the CCTDI. The Critical Thinking Disposition Assessment (CTDA), aimed at healthcare professionals and students, was developed by Yuan et al. (2014) with 19 sentences and a seven-point Likert response format, structured into three factors (Systematicity and Analyticity, Inquisitiveness and Conversation, and Maturity and Skepticism), which represented 63.40% of the variance and obtained an alpha between 0.86 and 0.94. With this test (CTDA) Cui et al. (2021) evaluated the dispositions of 278 students, obtaining good overall internal consistency (0.92) and in the three domains (0.81 – 0.86); confirmatory factor analysis (CFA) showed that the three-factor model fit the data.

Sosu (2013) developed a test of 11 items and two scales, Reflective Skepticism (4 items) and Critical Openness (7 items) and reported good alpha coefficients of the total scale (0.79 and 0.81), confirming the two-factor structure with CFA. In Turkey, Akin et al. (2015) applied this scale to university students and confirmed the structure and reliability of the total scale (0.78) and reported lower alpha coefficients for the scales (0.75 and 0.68), whereas Arslan (2015) used this scale to investigate the relationship of dispositions and meta-cognition.

The content of the CCTDI items and their assignment to scales is also debatable, as some might be inappropriate for young people. For example, the question "reading is something I avoid, if possible" assigned to Maturity, could also be considered as belonging to Inquisitiveness because of its content. Other phrases are complex and difficult to understand (e.g., "I am honest enough to face my own prejudices, inclinations, stereotypes, or self-centered tendencies"). Others require adaptation to young people's contexts; for instance, the item "most university courses are not interesting and not worth attending" does not make sense for young people who have not reached the university. Finally, other items are dispensable because they offer repeated content or are so generic that it seems impossible to disagree with them (e.g., "I apply my knowledge when necessary"). Developing a test adapted to young students requires raising issues that are comprehensible to them, shortening the test by eliminating repetitions, and refining the items of the scales.

From the conceptual perspective, the term dispositions, used to describe affective-psychological tendencies towards CT, seems less functional than the term attitudes, so we propose this conceptual change. Indeed, attitude is a construct with a long and solid tradition of research in Social Psychology: "a psychological tendency that is expressed when evaluating a specific entity to a favorable or unfavorable degree" (Eagly & Chaiken, 1993, p. 1) and fits the case perfectly. In fact, many CT studies use the term attitudes to refer to dispositions (Ennis, 2008; Facione et al., 1995; Ku, 2009; Sosu, 2013), and some antecedents such as the seminal definition of Glaser (1941) or the taxonomy of Authors (2019) make the term attitudes towards CT explicit.

The theoretical framework of Social Psychology (Eagly & Chaiken, 1993) offers a solid foundation for attitudes, which allows them to be differentiated from other similar concepts (beliefs, habits, values, opinions, standards, motivation, etc.), to apply Likert scales and to clarify the status of some elements of CT (self-confidence, well-being of others, ability, sensitivity) that have caused controversies (Ennis, 1996; Perkins et al., 1993). However, as research uses both terms interchangeably, herein a balance of dispositions-attitudes towards CT is maintained, affirming the founding theoretical framework of the construct attitudes.

In sum, research on CCTDI has questioned its validity and reliability in different cultural contexts and tends to apply reduced versions of it (Incikabi et al., 2013; Sosu, 2013; Yuan et al., 2014) or new instruments (Walsh & Hardy, 1997). In addition, as the CCTDI is for adults, the extension of twenty-first century skills and CT teaching in the educational system to younger students requires new assessment tools that include the youth. This study aims to address this problem by creating an attitude assessment test for young people, simultaneously taking into account the tradition of the CCTDI and the research that suggests shorter tests. The objectives of this study are: to develop a new shorter instrument to evaluate Attitudes towards Critical Thinking (QATCT) for young people and to verify the evidence of its psychometric properties.

3. Method

A two-stage process was developed to pursue these objectives, which involves a first application of an initial test to a sample of young people; based on its results, a new instrument is developed and applied to a new sample to find out validity and reliability. Thus, the procedures are previously displayed in order to better understand the instruments and the participants.

3.1. Procedures

The researchers performed the adaptation, translation, review, and analysis of the CCTDI items to ensure their proper

comprehension by young people. Consequently, we made some decisions about the creation, elimination, reformulation, and reallocation of the items among the various scales, which produced an initial pilot questionnaire with 60 items distributed among the seven original scales of the CCTDI. It was applied to a pilot sample of Spanish students using a 7-point Likert response format, to verify their comprehension and perform exploratory factor analyses (EFAs) related to its reliability and validity.

The analysis of the items about the comprehension of the issues and the responses of the young people of the initial pilot sample as well as the reliability and validity parameters obtained led to a series of decisions to improve comprehension and make the wording clearer and more precise. These decisions included removing 18 items from the pilot version, reformulating another 21 items, and reassigning items among the scales. As a result, a final 42-item questionnaire was developed, which we call Questionnaire of Attitudes towards Critical Thinking (QATCT). In the second stage, this instrument was applied to a new sample and subjected to new exploratory and confirmatory factor analyses (CFA).

The two instruments, initial and final, were applied to the participants by their teacher within their class group as a regulated class activity and following the same common standardized guidelines, using digital devices, without strict time limit (usually one class period), and especially motivating the students to ask them about the comprehension of the items.

3.1.1. Data analysis

The content validity of the instruments is based, in part, on the validity of the original source (CCTDI), whose translated items served as an inspiration to create this new test. The agreements about contents, scales, and the students' evolutionary level and about modifying, including, and discarding items were resolved by consensus of the authors' professional judgment, based on the contents of the sentences and the psychometric parameters obtained in the initial pilot study.

The databases with the responses were subjected to previous quality control and processed with SPSS (version 25) and the Factor program (April 2021 version). This allows applying a method of robust unweighted least squares (RULS) based on polychoric correlations, which is appropriate for the data of the Likert scale (1–7) used and for the EFA and CFA based on the factors extracted with the RULS method (Ferrando & Lorenzo-Seva, 2017, 2018). Reliability was calculated using Factor and RULS with various indices, Cronbach's alpha, the expected a posteriori index (EAP), and McDonald's omega. The AMOS program complements the analysis of structural equations on the latent variable model of scales and observable variables and its CFA statistics (Byrne, 2001; Kline, 2005).

Analysis of the data indicated that they satisfy some assumptions required for different statistical tests (Knapp, 2018). The levels of skewness and kurtosis were in the recommended range (± 2.0), with only one exception, and the correlation between variables was less than 0.9, which allows ruling out multi-collinearity.

3.1.2. Instruments

This study applied the two versions of the QATCT instrument in the two stages. The structure of both tests reflects the seven scales of the original CCTDI with slightly different names to fit better in Spanish (Curiosity – equivalent of inquisitiveness -, Truth-Seeking, Analysis, System, Open-Mindedness, Self-Confidence, and Prudence – equivalent of maturity -).

In the initial stage, the 60-item instrument was applied to a pilot sample, but it was soon reduced to 56 items (8 per scale) after eliminating 4 deficient items. The analysis of results suggests the elimination of 14 additional items and the modification of others to improve the validity of a second, final version consisting of a total of 42 items (6 per scale). In the second stage, this final QATCT was applied to a new sample of students to check its psychometric properties.

The QATCT instrument includes modifications to the original CCTDI. The names of some scales are not a literal translation of the original, the evaluation of the items by the students uses a seven-point Likert scale (1–7), and some sentences are drafted negatively regarding the scale they represent (e.g., "I rush into my decisions" of the Prudence scale), so their scores are reversed, such that higher scores correspond to better attitudes.

3.1.3. Participants

Two different convenience samples participated in each stage of this study (Table 2). In the initial pilot stage, the 60-item instrument was applied to a sample of 108 students aged 12 and 13 from three different schools. In the final stage, the 42-item instrument (QATCT) was applied to a convenience sample of 529 students aged between 11 and 15 years, belonging to ten different schools. The final sample size meets the requirements of EFA and CFA (Kline, 2014; Lloret-Segura et al., 2014).

Table 2
Demographic characteristics of the sample.

Variables	Values	Initial pilot study		Final study	
		Frequency	Percentage	Frequency	Percentage
Gender	Girls	86	79.6	297	56.1
	Boys	22	2.4	232	43.9
Age	11			66	12.5
	12	18	16.7	170	32.1
	13	90	83.3	44	8.3
	14			160	3.2
	15			89	16.8
Level	Primary Ed.	18	15.7	85	16.1
	Secondary Ed.	90	84.3	444	83.9

4. Results

4.1. Initial pilot study

In this stage, 60 items distributed in seven scales were administered, each scale with 8 or 9 items. The mean scores of the 60 items ranged from 6.33 (highest) to 3.09 (lowest), an asymmetric range concerning the midpoint (4), which indicates that the students' responses tend to be mostly oriented towards agreement. All skewness and kurtosis values were in the range of ± 2.0 , except for four items.

Correlational analyses identified four items (10, 12, 50, 60) that were eliminated early on because of their poor parameters. The EFA for the remaining 56 items did not yield appropriate results to reproduce the theoretical model of seven scales. We identified 14 items with negative or null correlations, with negative or null factor loads on the empirical factors, or with both criteria, which justified their elimination. Another 20 items showed minor psychometric deficiencies (some parameter outside the desirable limits) so their content was reviewed and reformulated. In addition, the reliability indices of the seven theoretical scales and empirical factors were low, although the full test showed good reliability (0.871).

4.2. Final study

In the second stage, we administered the 42-item QATCT resulting from the eliminations and revisions of the initial pilot test, which maintained the structure of seven scales of the CCTDI, with six items each. Most of the items had mean scores above the central point (4), and only three items had lower scores (Fig. 1). All skewness and kurtosis values were in the range of ± 2.0 except for one item.

4.3. Factor analysis of the final stage

The database of the final study was subjected to various correlational analyses, including EFA and CFA with the Factor program.

The polychoric correlations matrix showed adequate values to perform EFA: excellent Bartlett's statistic and very good Kaiser-Meyer-Olkin (KMO) test (0.90876). The list of eigenvalues showed nine values greater than the unit, which explained 56.1% of the total variance; the rule of Kaiser (1970) -eigenvalues > 1 - suggested a maximum of nine factors for the empirical model, which would fit the 42 observable variables. In addition, the first eigenvalue was very relevant, as in all the models tested, it produced a dominant empirical factor that explained 25.2% of the total variance, with high loads on a dozen variables and the highest reliability values. On another hand, the increase in the explained cumulative variance in the successive factors showed a significant stagnation as of eigenvalue six, suggesting a six-factor model.

Three models were studied with nine, seven, and six empirical factors that would explain between 51.0% and 48.3% of the variance of the total questionnaire (Table 3). All three models produced good and similar values of the goodness-of-fit statistics, but the differences between the three models appeared in the values of the reliability of the empirical factors and the factor loads of the rotated matrices of each model in relation to the theoretical model of seven scales.

Reliability analysis of the empirical factors of the three nine-, seven- and six-factor models (Table 3) showed that the six- and seven-factor models yielded empirical factors with higher reliability values than the nine-factor model. The six-factor model had the best reliability values, as it lacked factors with low reliability values, only two factors had a moderate value ($\text{Orion} > 0.70$), and the remaining four factors had very good values ($\text{Orion} > 0.80$).

The comparison of the factor loads of the rotated matrices in the three models of empirical factors explored here indicated that all

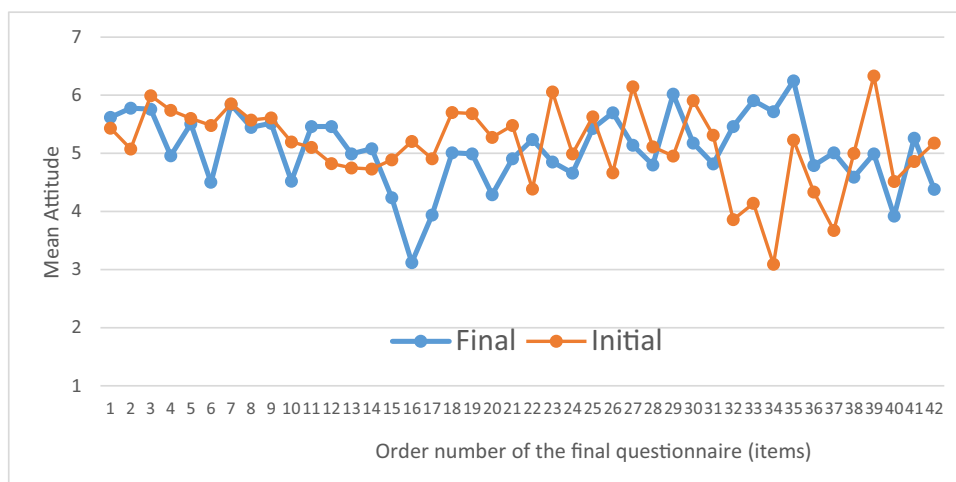


Fig. 1. Means of the 42 items of the Attitudes towards Critical Thinking questionnaire (ATCT), common to the initial pilot and final study.

Table 3

Reliability coefficients (Orion) for three models with nine, seven, and six empirical factors obtained with the Factor program (polychoric correlations, robust RULS method, and Promin rotation).

Models	Number of eigenvalues/factors								
	1	2	3	4	5	6	7	8	9
Cumulative variance explained by eigenvalues	.252	.326	.38	.419	.455	.483	.510	.537	.561
Orion Reliability									
9 factors	.921	.713	.790	.847	.477	.577	.774	.662	.708
7 factors	.921	.835	.704	.814	.772	.652	.764		
6 factors	.775	.721	.808	.914	.813	.846			

three models coincided in: sharing the structure of one main factor (System), superimposing variables of two different scales (Analysis and Prudence) on an empirical factor, and roughly reflecting the remaining theoretical scales. The most decisive differences concerned the existence of empirical factors that lacked interpretation because no item loaded appreciably on them—the nine-factor model displays three meaningless factors and the seven-factor model displays one meaningless factor—whereas the six-factor model offered a coherent meaning for all factors.

These results suggested that the six-factor empirical model was the most coherent and parsimonious to represent the empirical data. The analysis of its matrix of rotated factor loads (Table 4) allowed the most coherent and approximate interpretation regarding the original seven-scale model, the basis of the QATCT questionnaire, although two empirical factors presented new fused structures. In short, the six-factor empirical model offered the best reliability values and the most coherent and parsimonious interpretation but it provided two differential novelties.

Fundamentally, in the factor load matrix of the six-factor model, we could recognize its relationship with the theoretical seven-scale model of the CCTDI within the empirical factors obtained (Table 4). The items of the first, second, third, and sixth factors roughly identified them with the original theoretical scales (Self-Confidence, Truth-Seeking, Open-Mindedness, and Inquisitiveness). The differential is that the new structure of the scales provides a new theoretical model with two main innovations concerning the CCTDI model: on the one hand, the fourth factor, dominant and the main factor of the model, is basically identified with the six items of the Systematic theoretical scale, but it adds five items transferred from other scales; on the other hand, the fifth factor merges four items of the theoretical scale of Prudence with three items of the theoretical scale of Analysis. Finally, some cross-loadings between factors require further confirmation studies and decisions about them (the OPEN40 and OPEN43 items of the Open-Mindedness factor and the ANALY22 of the Prudence-Analysis factor).

The new six-factor model was supported by favorable values of all the CFA statistics. The values of RMSEA (0.008), NNFI (0.999), and CFI (0.999) were excellent, and the GFI (0.987) and AGFI (0.982) indices were also very good.

In short, the results confirmed the validity and reliability of the QATCT to evaluate attitudes toward CT. The structure presents six new scales (Table 4), four of which have similar content to the original scales (Truth-seeking, Self-Confidence, Inquisitiveness, and Open-Mindedness), and two are different (System and Prudence-Analysis).

4.4. One-dimensional validity and reliability of the six new scales

According to the structure of variables empirically assigned to each scale (Table 4) the one-dimensional nature of each of the six new scales of the QATCT was contrasted with a CFA of the Factor program, which also assesses several reliability indices for each scale (Ferrando & Lorenzo-Seva, 2017, 2018).

The fit to a one-dimensional model (single factor) of each of the six new scales presented positive factor empirical loads, with high values in most of the items (last column of Table 4). The 42 items have loads higher than 0.3 and most of the items (33) have loads higher than 0.5, which is the first favorable indicator of the verification of the one-dimensional model for each of the new scales.

The confirmatory parameters of the validity and reliability of the one-factor model for the six new scales are summarized in Table 5. The adequacy statistics of the polychoric correlation matrix, Bartlett's statistic and the Kaiser-Meyer-Olkin statistic, show favorable values to the one-factor model in the six scales; in addition, the variances explained by a single factor reach relevant values (36% to 51%).

The MIREAL parameters, which contrast the one-dimensionality, are favorable in all six scales, which confirms the one-factor model for the six scales of the QATCT. Robust goodness-of-fit statistics of the one-factor model are also favorable for all six scales; the absolute fit parameters (RMSEA, χ^2) are favorable in all cases, although the Truth-Seeking scale is at the limit of the criterion. Incremental goodness-of-fit indices (NNFI, CFI, and GFI) are excellent for all six scales.

Finally, all the unique factors also achieve adequate reliability values. The Factors Curiosity, System, and Truth-seeking tend to present very good reliability, better than the other three scales (table 5). Further, the overall reliability of the 42-item test is excellent (omega, 0.914; alpha, 0.918).

The good convergent validity of the QATCT was evaluated through Pearson correlations between the six new scales emerging from the CFA, with positive and significant results ($p < .01$) (Table 6). The Prudence-Analysis scale presents the lowest correlations.

In summary, the CFA and reliability results confirm that each of the six new empirically obtained scales has a valid one-factor structure and good reliability, so their scores can be treated as one-dimensional.

Table 4

Matrix of factor loads resulting from the CFA for the 42 items of the ATCT (robust RULS method and Promin rotation of the Factor program) for the six-factor model and the one-dimensional single-factor model applied to each new factor.

Items*	Order Nr.	Six-factor model (new)						Single factor
		Self-Confidence	Truth-seeking	Open-mindedness	System	Prudence-Analysis	Curiosity	
OPEN37	25			.648				.716
OPEN39	26			.558				.713
OPEN40	27			.302	.510			.695
OPEN43	28			.167	.341			.412
OPEN44	29			.631				.540
CONFI15	11	.451						.512
CONFI45	30	.367						.482
CONFI46	31	.546						.327
CONFI47	32	.541			.482	.438		.732
CONFI49	34	.493						.520
CONFI51	35	.342						.683
CURIOS1	1						.479	.601
CURIOS3	2						.698	.699
CURIOS5	3						.810	.684
CURIOS7	5						.702	.701
CURIOS9	7						.334	.625
TRUTH11	8						.345	.528
PRUDEN20	40					.668		.623
PRUDEN24	16					.471		.362
PRUDEN35	42					.697		.414
PRUDEN54	38					.686		.723
ANALY26	17					.358		.473
ANALY29	20					.406		.535
ANALY22	15		.338			.309		.518
SISTEM27	18				.452			.510
SISTEM28	19				.632			.651
SISTEM30	21				.679			.657
SISTEM32	22				.595			.622
SISTEM34	23				.407			.395
SISTEM55	39				.682			.698
PRUDEN36	24				.711			.702
PRUDEN21	14				.572			.570
ANALY53	37				.717			.699
ANALY19	13				.672			.635
OPEN41	41				.542			.639
ANALY14	33	.309	.440					.387
TRUTH13	9		.105					.445
TRUTH17	12		.128					.473
TRUTH52	36		.343					.527
TRUTH59	6		.415					.449
CURIOS6	4		.570					.563
TRUTH14	10		.317	.304				.630

* Each item is named with the acronym (in capital letters) of the new factor names and the number assigned in the initial questionnaire (loads < 0.30 eliminated from the table).

4.5. Structural equation model

The factor structure of the QATCT was verified through structural equations of CFA with AMOS 26.0.0.0 (Byrne, 2001; Kline, 2005). A model was contrasted with six first-order latent variables that are related to the observable variables (items) according to the new scales deduced from the empirical factors (Table 4) and an additional second-order latent variable (attitude), related to the six latent variables, which could be interpreted as the general DACT attitude (Fig. 2). The variances of the latent variables were set at 1, the variances of the error terms were specified as free parameters, and the estimates of the fit parameters were calculated with the maximum likelihood method, justified by the adequate values of kurtosis in the observable variables (Kline, 2005).

The model iteratively estimates interactions between the residues of the same observable variable and the latent variables, which explore the significant covariances between residues until the modifications do not provide any relevant improvements to the estimates (not included in Fig. 2 to facilitate comprehension). The covariances between the six latent variables are statistically significant, with the exception of the covariance between Prudence-Analysis and Self-Confidence. Additionally, the correlations between the six empirical factors are low (between -0.069 and 0.581), and analogously, the mutual correlations between the six theoretical scales (between 0.110 and 0.646) are lower than the 0.80 value, and this result supports the discriminant validity of each construct (Brown, 2006).

The latent variables that had the highest standardized regression weights in relation to attitude (Fig. 2) were Open-Mindedness (0.893), System (0.795), Truth-Seeking (0.806), Curiosity (0.877), and Self-Confidence (0.828), and they were lower for the latent

Table 5

Statistical parameters of the assessment of one-dimensionality, goodness of fit of the one-factor model, and reliability for each of the six new emerging scales of the analyses of the ATCT.

Statistics	New scales Open-mindedness	Self-Confidence	Curiosity	Prudence-Analysis	System	Truth-seeking
Adequacy						
Bartlett (p)	.000000	.000000	.000000	.000000	.000010	.000000
K-M-O test	.79777	.77240	.84277	.80381	.91390	.73904
Explained Variance	.50597	.41769	.50875	.38031	.44099	.35599
Unidimensionality						
MIREAL*(<0.30)	.214	.234	.231	.201	.157	.288
Goodness of fit						
RMSEA**(<0.05–0.08)	.027	.038	.051	.044	.041	.081
$\chi^2(p > 0.05)$.883	.953	.953	.984	1.000	.984
NNFI**(>0.90)	.995	.985	.985	.976	.989	.901
CFI**(>0.90)	.998	.991	.991	.984	.991	.934
GFI**(>0.90)	.996	.994	.995	.991	.992	.978
Reliability						
EAP***	.784	.760	.815	.759	.881	.712
Omega	.758	.718	.807	.726	.872	.872
Cronbach's alpha	.749	.713	.806	.721	.870	.870

* MIREAL (Mean of Item Residual Absolute Loadings).

** RMSEA (Root Mean Square Error of Approximation); NNFI (Non-Normed Fit Index); CFI (Comparative Fit Index); GFI (Goodness of Fit Index).

*** EAP (Expected a Posteriori Reliability).

Table 6

Pearson correlations between the scores of the new scales ($n = 529$).

	Open-mindedness	Self-Confidence	Curiosity	Prudence-Analysis	System
Self-Confidence	.481**				
Curiosity	.514**	.490**			
Prudence-Analysis	.175**	.110*	.121**		
System	.646**	.402**	.553**	.284**	
Truth-seeking	.414**	.394**	.463**	.343**	.416**

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

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

variable Prudence-Analysis (0.358). The regression analyses of the six latent variables with regard to the observable items assigned to each one were all significant, and the standardized regression coefficients of each observable variable were almost all (39) higher than 0.30, except for three of them (0.286, 0.285, 0.220). These regression results show that the constructs of the model have convergent validity (Kline, 2014).

The goodness-of fit-indicators obtained for this model were: $\chi^2(778) = 1565.9$; $p < .0001$; χ^2 divided by the degrees of freedom (CMIN/DF) was excellent (2.013), and RMSEA was also excellent (0.044; 90% confidence interval [.041, 0.047]): the parsimony fit measure was also good (PRATIO, 0.904) and the incremental fit indices (CFI = 0.869; TLI = 0.856; GFI = 0.874) were close to the acceptance threshold (0.90).

In short, the CFA structural equations empirically corroborated the factor structure of the new model, as it presented good fit statistics for the observable variables.

5. Discussion and conclusions

This study aimed to address the lack of tests to evaluate DACTs in young people and to overcome the dysfunctions of the CCTDI inventory identified in some studies, following the tendency to develop shorter tests. Based on the theoretical model of seven factors of the CCTDI (Facione et al., 2001), a 42-item questionnaire of Attitudes towards Critical Thinking (QATCT) was designed and validated in a two-stage process.

Through CFA, the results confirm the validity and reliability of a six-factor empirical model for QATCT: System (11 items), Prudence-Analysis (7 items), Truth-Seeking (7 items), Self-Confidence (6 items), Curiosity (6 items), and Open-mindedness (5 items). The reliability coefficients of the overall instrument (omega, 0.914) and of the six scales were high (0.712 - 0.881); in addition, solid evidence of reliability and validity demonstrated the one-dimensionality of the six scales, which guarantees their independent use (Ku, 2009).

The structure of QATCT presents the expansion of the dominant scale System with five items, transferred from other scales, and a new factor (Prudence-Analysis) that integrates four items of the original prudence with three items of the original analysis. In addition, the content analysis of the transferred items supports these empirical innovations. Indeed, the four items that expand the new System factor begin with the adverbs "when" and "before", which suggest organized and diligent forecasting, typical of the scale in which they

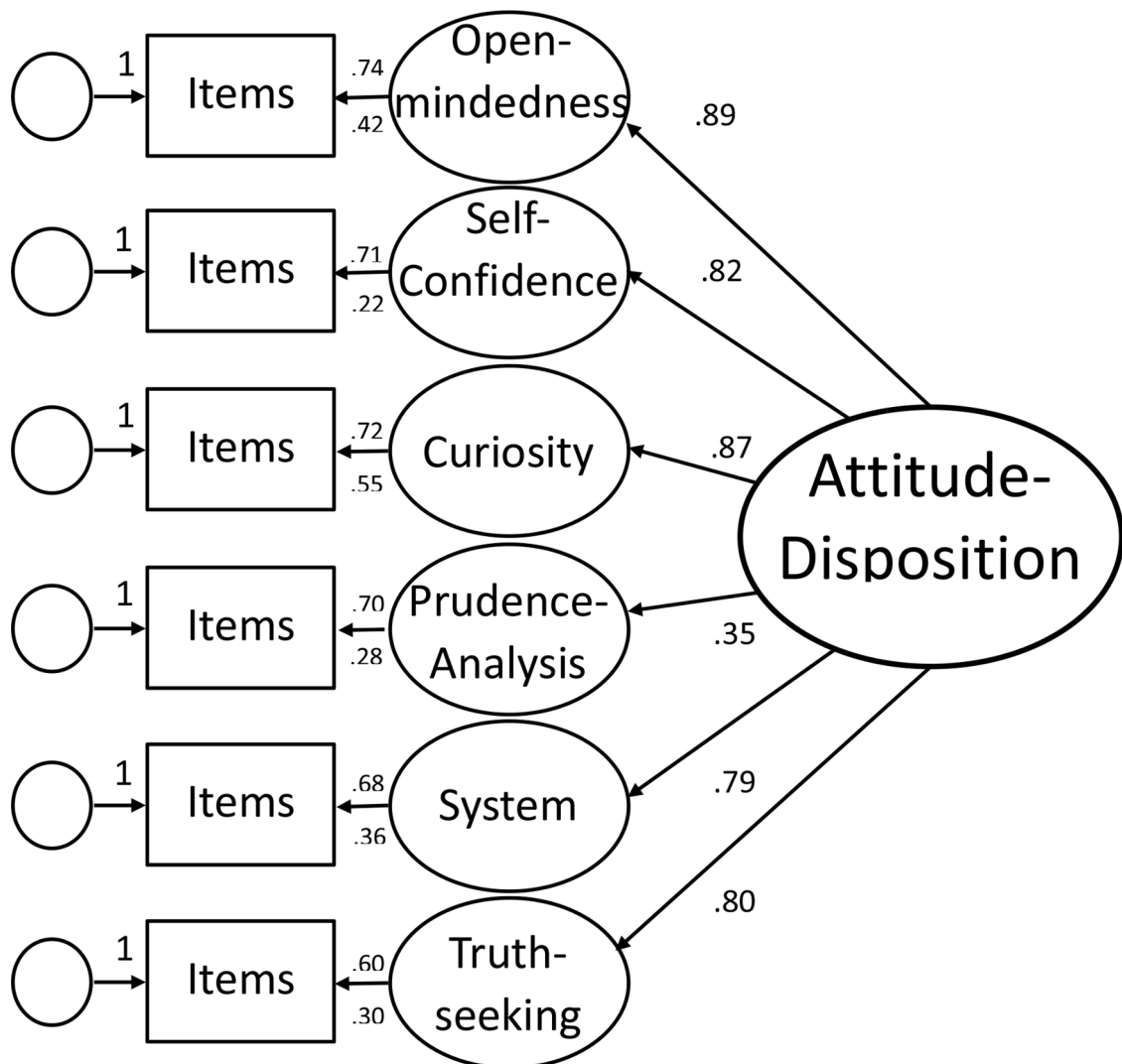


Fig. 2. Standardized regression coefficients between variables in the confirmatory factor analysis of the model of six latent factors for the final data with AMOS 26 (for each group of observable items, the maximum and minimum coefficients are indicated).

are integrated (System) and which justifies the transfers. The CFA supports this new structure resulting from transferring items to scales other than the original CCTDI scales because it provides better validity and reliability for the QATCT.

This study is methodologically innovative in several respects. At the theoretical level, it promotes the change from the denomination of dispositions to that of attitudes to designate a person's psychological tendency toward CT because the theory of attitudes consolidated in Social Psychology provides greater theoretical solidity (Eagly & Chaiken, 1993). In addition, previous empirical approaches based on EFA (Facione & Facione, 1992) were innovated herein with CFA and robust methods of polychoric correlations. Finally, the confirmed structure of QATCT's six-factor model incorporates elements from other existing taxonomies and is more parsimonious than the CCTDI model (Facione et al., 2001).

The study also has practical and research implications. The confirmed structure of the QATCT makes it a useful and flexible tool to measure DACTs, and the one-dimensional robustness of the scales allows their independent use in the form of a shorter instrument to guide research (Ku, 2009). In addition, the QATCT can be used in diagnosis and orientation to identify the deficient attitudinal aspects of CT (Ennis, 2008; Ku, 2009).

However, the use of the instrument should take into account some limitations. The QATCT only measures the attitudinal facet of CT and should be combined with other measures for a more complete understanding of the personal CT profile (Ennis, 2008; Ku, 2009). In addition, the QATCT measures general attitudes, and attitudes in specific domains may differ, although specialists consider that general attitudes help to prove the transferability between domains (Ennis, 2008; McPeck, 1990; Perkins et al., 1993). The sample of this study is large but limited, and it is expected that new samples will contribute to consolidating the evidence of validity and reliability and standardizing the instrument. The predictive validity of attitudes is a pending and controversial challenge for research, as

previous results are confusing (Cui et al., 2021; Sosu, 2013; Wang et al., 2019; Yuan et al., 2014).

Finally, attitudes towards CT share universally recognized civic virtues (discernment, coherent behavior, and pursuit of knowledge, truth, and comprehension) that contribute to the development of virtuous individuals and societies (i.e., Jubilee Center for Character and Virtues, s. f.). This coincidence opens a new line of development for attitudes towards CT and its evaluation as active contributors to character education and civic virtues. This proposal connects with an apparent limitation of this study, more specifically the lack of the explicit inclusion of collaboration as a social thinking attitude, because collaboration involves the elaboration of thinking in groups, thinking about social issues, and the development of teamwork (which is an essential interpersonal skill of the 21st century). All these reasons suggest that collaborative attitudes must be explicitly considered to better account for attitudes towards CT (Davies et al., 2018).

CRedit authorship contribution statement

María Antonia Manassero-Mas: Conceptualization, Software, Writing – review & editing, Supervision, Funding acquisition, Project administration, Writing – original draft. **Ana Moreno-Salvo:** Conceptualization, Methodology, Visualization, Data curation, Investigation, Writing – review & editing. **Ángel Vázquez-Alonso:** Conceptualization, Methodology, Software, Data curation, Validation, Writing – original draft, Writing – review & editing.

Declarations of Competing Interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.tsc.2022.101100](https://doi.org/10.1016/j.tsc.2022.101100).

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Further reading

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