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Translation and Psychometric Properties of Critical Thinking Scale for Adolescents

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Abstract
The Critical Thinking Scale is a tool used to measure many aspects of critical thinking, such as analysis, evaluation, inference, interpretation, explanation, and self-regulation. The goal of this study was to translate and examine the psychometric qualities of the scale for teenagers. The scale's validity, reliability, and usefulness for use in evaluating teenagers' critical thinking skills in a secondary school setting were to be ascertained. For the study, a sample of 500 teenagers from Pakistani secondary schools was chosen. Participants were given the Critical Thinking Scale after it was translated into Urdu. Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), correlation analysis, and descriptive statistics were used to analyses the data. Internal consistency was evaluated using Cronbach's alpha, and the scale's structure and measurement fit were confirmed using EFA and CFA. This study translated and evaluated the validity and reliability of the Critical Thinking Skills Scale (CTSS). Forward and backward translation approach developed by Sousa and Rojjanasrirat (2011) used as a research design. 500 adolescents were selected based on convenience sampling and asked to complete the CTSS questionnaire for psychometric testing. We evaluated translation equivalence, the item content validity index, floor/ceiling effects, construct validity, internal consistency reliability and test–retest reliability. The CTSS questionnaire retained the meaning of the original English version and was clear, explicit and easy for adolescent to understand. The Cronbach's alpha was 0.722. The CFA further supported the validity of the scale, with fit indices for most dimensions falling within the acceptable range. Confirmatory factor analysis indicated that this Urdu version fit the proposed model.
Keywords: critical thinking, translation, self-regulation, psychometric properties, etc.

Introduction
The variety of populations around the world indicates a critical need for cross-culturally validated studies questionnaires or scales. Sousa and Rojjanasrirat

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(2011), in order for researchers to be able to carry out cross-cultural studies and/or provide quality education, they need to have access to instruments that are trustworthy and valid with an interesting concept in their own cultures and languages. The production of a questionnaire necessitates the expenditure of both time and financial resources. To begin, the process of developing the questionnaire and selecting the domains and items that will study the construct of interest in the most effective manner (Shoulders et al., 2014).

Epstein et al. (2015), the second step is to validate and ensure that the questionnaire accurately assesses the variables that it is intended to measure. It is therefore possible to save time and effort by making use of questionnaires that have been established in the past and have good psychometric qualities (Mundy & Denham, 2008). These questionnaires, on the other hand, need to be valid in the sense that they are culturally acceptable and adequately translated (Cha et al., 2007). As a consequence of this, the process of translation and psychometric evaluation becomes a key component of investigations that involve multiple cultures (Chao et al., 2013). A variety of definitions relating to the notions of cognition, attitude, process, and skills have been proposed for critical thinking. These definitions have been discussed from the perspectives of multiple disciplines. Even if there is no clear consensus on a definition of critical thinking, many academics are in agreement that it is essential and beneficial in the field of education (Chan, 2013).

Critical thinking is a cognitive process that symbolizes the ability to apply reasoning with the intention of reducing errors in decision-making (Alfaro-Lefevre, 2016; Shinnick & Woo, 2013; Guillemin & Shepherd, 2020; Lee et al., 2017). In the field of education, critical thinking includes the ability to apply reasoning. Critical thinking is recognized and supported by a number of professional organisations (Brunt, 2005; Mundy & Denham, 2008; Simpson & Courtney, 2002). These organisations acknowledge that critical thinking is a crucial component in the function of development (Zuriguel-Pérez et al., 2015). Bambini et al. (2009), adolescents use their critical thinking abilities on a daily basis in order to evaluate, plan, and offer comprehensive patient care (Ludin, 2018). The ability to think critically has been linked to the ability to make decisions (Bowles, 2000; Martin, 2002), the ability to solve problems (Lunney, 2010), and the utilization of research (Profetto-McGrath et al., 2003).

Zuriguel-Pérez et al. (2017) and Carter et al. (2015) discovered that there was a lack of reporting regarding the reliability and validity of instruments, as well as inconsistent findings across a number of research. This led to skepticism regarding the validity of these measures when applied to situations involving adolescents. Zuriguél-Pérez et al. (2017), the psychometric assessment of the initial CTSS questionnaire demonstrated that it possessed high levels of validity and reliability. Over the course of the past two decades, critical thinking has been given a lot of attention and has been the subject of discussion in educational settings in particular.

The nature of knowledge, the manner in which learning takes place, and the fundamental beliefs of the roles of students and teachers have all undergone

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significant changes, which is the primary reason for this phenomenon (Özden, 1998). According to the various pieces of literature that pertain to critical thinking, it is possible to see that there are numerous definitions that pertain to it. Clark (2019) compares this process, which deals with the definition of high-level thinking skills, to a swamp that cannot be extracted. Critical thinking can be classified in a variety of different categories like a) the problem of defining the concept of thinking from Ancient Greek up to the current time; b) the constant perception of critical thinking as a negative process of thinking; c) the fact that researchers who are attempting to describe critical thinking have a tendency to explain it by considering it from the perspective of many fields of study such as education, psychology, and philosophy.

Due to the reasons given above, researchers have attempted to define critical thinking by focusing on the characteristics that set it apart from other types of thinking and that vary depending on the field of study. Walsh and Paul (2022) considered critical thinking to be a skill that can be improved by any individual. They emphasized that critical thinking should not be confused with the idea of intelligence and that it should not be confused with intelligence. Ennis (2019), who focused more on the teaching aspect of critical thinking, critical thinking is defined as the process of thinking about an individual in a way that is both reasonable and profound while deciding what he did and believed. This study aimed to translate the English CTSS Questionnaire into Urdu (CTSS) and to examine its validity and reliability with a sample of adolescents and also to determine the psychometric properties of translated and adapted scales of Critical Thinking Skills Scale (CTSS).

The ability to analyses, evaluate, and synthesize information for the purpose of decision-making and problem-solving is referred to as critical thinking (CT), and it is considered to be an essential component of cognitive development (Facione, 2020). Due to the fact that adolescence is a time of increased cognitive development and change, the development of cognitive behavioral therapy is especially crucial during this stage of life. Higher-order thinking abilities are essential for academic achievement, informed decision-making, and successful problem-solving in real-life settings (Halpern, 2014). Children and adolescents develop these skills during their formative years. The evaluation of CT among adolescents, on the other hand, calls for the utilization of trustworthy and culturally pertinent methods that are capable of capturing the distinctive developmental and contextual elements of this age group.

The Critical Thinking (CT) has been measured using a variety of scales, such as the California Critical Thinking Disposition Inventory (CCTDI; Facione et al., 1995) and the Watson-Glaser Critical Thinking Appraisal (WGCTA; Watson & Glaser, 1980). Since the majority of these instruments were established in Western contexts, there are questions over their usefulness in a variety of cultural situations, despite the fact that they have received widespread validation. According to Wang and Sun (2018), the necessity for cross-cultural validation is especially crucial because cultural norms and educational practices have a substantial impact on how CT emerges in different populations.

CT scales continue to maintain semantic and conceptual equivalence across

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different languages and cultures, translation and adaption of these scales are highly important. Beaton et al. (2000) presented a comprehensive method for translation that included forward-translation, back-translation, expert panel evaluations, and pretesting. The purpose of this method was to improve the cultural and linguistic validity of the translation. In his pioneering work on translation methodology, Ferraz (2019) emphasized that direct translations frequently fail to convey the cultural nuances of the original material. As a result, cultural adaptation is required in order to guarantee relevant evaluation. For instance, idiomatic idioms or references that are culturally specific in the source language might not have direct equivalents in the destination language, which could possibly change the meaning that the scale was intended to convey about the culture. This issue is especially relevant for CT measures since the traits that they assess, such as open-mindedness, analytical reasoning, and skepticism, may be perceived differently in cultures that are more collectivist as opposed to cultures that are more individualist (Hambleton & Patsula, 2021).

The reliability and validity of translated CT measures, psychometric qualities are something that are absolutely necessary. Cronbach's alpha is a generally used method for evaluating reliability, which assesses the degree to which the scale is consistent within itself. Nunnally and Bernstein (2022) proposed that an appropriate level of reliability is indicated by a Cronbach's alpha of 0.70 or higher. Giancarlo and Facione (2001) indicated that CT scales had a high level of reliability in adult populations. However, when used to adolescents, comparable measures can occasionally produce lower levels of reliability due to changes in their developmental stages. According to Steinberg (2005), the cognitive abilities of adolescents are still in the process of maturing, which can have an effect on how consistently they react to items that measure abstract concepts such as CT. On the other hand, validity requires consideration of a number of different aspects. The exploratory and confirmatory factor analyses (EFA and CFA) are frequently utilized in the process of determining whether or not a scale accurately measures the desired theoretical construct. This particular aspect of construct validity is evaluated.

Through the use of CFA, Facione et al. (1995) were able to confirm the CCTDI and identify distinct characteristics of CT, such as truth-seeking and inquisitiveness. However, when the scale is adapted for adolescents or other cultural contexts, these features may vary, which is why more validation studies are required to ensure the scale's applicability (Hatcher, 2013). Another essential component is criterion-related validity, which entails establishing a correlation between the newly developed scale and current measures of comparable constructs or outcomes that are relevant to the scale. For example, Halpern (2014) emphasized the fact that CT skills have a substantial correlation with academic success. This provides a basis for verifying CT scales by utilizing educational indicators.

Wang and Sun (2018) found that people' approaches to critical thinking are influenced by cultural norms. For instance, in cultures that place a strong premium on social harmony, critical questioning, which is an essential component of conversational therapy (CT), may be repressed since it may be interpreted as

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confrontational. As a result of these cultural idiosyncrasies, adjustments are required in order to guarantee that CT scales are applicable to the community that is being targeted. The CCTDI was adapted by Ku (2009) for use with East Asian students, and they found that there were substantial disparities in the factor loadings between East Asian samples and Western samples. In order to explain these disparities, it was determined that cultural differences in educational procedures, societal expectations, and the importance that is put on critical discourse were responsible. Ahmad et al. (2021) emphasized the importance of culturally adapted CT evaluations that are in line with the educational systems, societal values, and languages of the local community in Pakistan. According to the findings of their research, the straight importation of instruments produced in the West frequently leads to poor psychometric performance and diminished validity.

The cognitive processing abilities of adolescents are distinct from those of adults because adolescents are still in the process of acquiring the capacity for abstract reasoning, argument evaluation, and decision-making based on evidence (Kuhn, 2021). In order to determine whether or not these modifications are appropriate for use with younger populations, tools like the Cornell Critical Thinking Test (Ennis & Millman, 1985) have been modified. However, in order to validate these modifications, extensive psychometric testing is required. In contrast to adult cognitive therapy, Kuhn (2021) suggested that adolescent cognitive therapy is distinguished from adult CT by the fact that it is characterized by an increasing ability to explore different views and analyses data critically. In order to guarantee the validity and reliability of CT measures for teenagers, it is necessary to incorporate these developmental changes into both the structure and the content of the scales.

A number of obstacles must be overcome throughout the process of cross-cultural adaptation, one of which is the requirement to strike a balance between linguistic precision and cultural appropriateness. Hambleton and Patsula (2021) pointed out that translation without cultural adaptation frequently undermines the validity of the scale. This is because it does not take into account the differences in the manner in which different cultures understand and express notions. This is especially important to keep in mind when it comes to CT measures, as concepts like open-mindedness and skepticism can have drastically different meanings depending on the cultural context in which they are assessed. In individualist societies, for instance, skepticism may be regarded as a sign of intellectual rigor, but in collectivist situations, it may be regarded as a sign of distrust. These cultural differences highlight the significance of involving local specialists in the process of translation and adaptation in order to guarantee that the scale truly reflects the values and conventions of the audience that is being targeted.

Evaluation of the dimensionality of CT scales is another component of the psychometric validation process. The dimensionality of CT scales might change depending on the population that is being evaluated. In their research on CT scales for East Asian students, Ku (2009) discovered that the characteristics of CT that were identified in Western contexts, such as analytical thinking and inquisitiveness, did not fully correlate with those that were detected in the East

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Asian sample. Based on these data, it appears that cardiovascular disease (CT) may present itself differently in different cultures, which calls for population-specific adaptations and validations. Ahmad et al. (2021) discovered that the factor structure of CT scales for Pakistani teenagers was different from those reported in Western samples. This finding highlights the importance of local educational and cultural contexts on the development of CT.

Rational of the Study

The methods used to test critical thinking (CT) in non-Western youth have not yet been modified and validated, despite a wealth of research on CT and its significance for cognitive and educational development. Because the Watson-Glaser Critical Thinking Appraisal (WGCTA) and the California Critical Thinking Disposition Inventory (CCTDI) were created in Western cultures, they are inappropriate for societies with distinct educational systems, social mores, and cognitive priorities. These approaches tend to ignore how CT manifests in collectivist environments, where values such as respect for authority and social harmony may influence teens' critical thinking in ways that differ from those found in individualistic cultures (Wang & Sun, 2018). To accurately reflect the cultural, linguistic, and developmental traits of teenagers in many locales—particularly in South Asia, where research is limited—CT measures must be localized (Ahmad et al., 2021).

Another problem is the paucity of psychometric validation studies on translated CT measures for teenagers. Adolescent growth necessitates particular scale adaptation and validation considerations, while these strategies have been verified for adults (Kuhn, 2021). Few research has looked at how CT dimensions vary in younger populations, despite the significance of abstract reasoning in teenagers (Steinberg, 2005). In order to prove construct validity and reliability in the target group, the few adaptation studies do not employ rigorous validation techniques such as confirmatory factor analysis (Hambleton & Patsula, 2021). In addition to providing educators and policymakers with more tools to support CT skills in a variety of cultural and educational contexts, addressing these shortcomings will increase the psychometric robustness and cultural relevance of CT scales for teenagers.

Translation of the Scale

Forward Translation

The corresponding translators are required to have prior experience in test development, as opposed to only being professionals in the field of translation. The Critical Thinking Skills Scale (CTSS) questionnaire are to be translated into the appropriate target language by two translators who was work independently from one another. When formulating their translations, the translators are tasked with using language that is natural and suitable for the widest possible audience, as well as being straightforward, clear, and succinct. The translators were always concentrating on conceptual equivalency rather than on literal word-for-word translation. Translators was constantly making an effort to understand the most important meanings of the English terminology they are translating and then

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translate them correctly. In their formulations, the translators were making an effort to be straightforward, clear, and succinct; they were avoid using lengthy phrases that contain a large number of clauses. It is important for the translators to take into consideration how the typical replies, which include both male and female, was comprehend the documents. It is important for the translators to take into account the ages of the people who are providing feedback, and as a result, they were avoid using any jargon or terminology that are difficult to comprehend. The translation ought to be understandable, straightforward, and easy to understand. It is important to avoid using double negatives.

Reconciliation of Items

A reconciliation meeting was be arranged in order to reconcile the two separate forward versions. The conceptual equivalency, comprehensibility, and clarity of speech of the two translations was be evaluated in relation to the Critical Thinking Skills Scale (CTSS). It is important for participants in the reconciliation process to record their evaluations item by item. They ought either pick the best translation or recommend a different one if neither is sufficient. They must to concentrate on cultural and linguistic variations that could make translating the English text into the target languages challenging. Through a follow-up conversation between the participants, a reconciled version was determined. The most accurate translations of the items are included in the Reconciled Forward Translation, such that;

Backward Translation

The purpose of the Backward Translation is to evaluate the conceptual equivalency between the Reconciled Forward Translation and the Critical Thinking Skills Scale (CTSS). The following requirements must be met by the backward translator i.e. be a native English speaker and fulfill all other requirements listed above (forward translator). The backward translator converts the Reconciled Forward Translation back into English. It is not expected that the reverse translator has previously worked with the Critical Thinking Skills Scale (CTSS). The backward translator may also be provided with the above-described guidelines (for forward translators).

Review of the Forward and Backward Translation

In order to give a Final Forward Translation, the review is intended to evaluate the complete forward-backward procedure. Two research group members who are proficient in both English and the target language. One of the translators who goes forward. External specialists having expertise in translating and developing instruments, if accessible. The English Aspects of Critical Thinking Skills Scale (CTSS) questionnaire was be compared with the backward translation in order to identify conceptual discrepancies. By contrasting the back-translated things with the English source items, the participants examine the translation item by item. Creating a Final Forward Translation document is the goal. The translation ought to be straightforward, understandable, and succinct. The Final Forward Translation of the Critical Thinking Skills Scale (CTSS) was not conceptually

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differed from one another. The emphasis is on employing common language and attaining conceptual equivalency and clarity.

Method

It is a correlational and cross-sectional study to examine the relations between different characteristics. Convenience sampling was used to choose the study's sample, which included adolescent attending both public and private schools in Faisalabad, Pakistan.

Sample

For the study, 500 participants—both male and female—between the ages of 13 and 18 were selected. G*Power software was used to calculate the sample size, guaranteeing sufficient power for statistical analyses and accurate findings. Both male and female of age 13 to 18 years was included in the sample. Participants from high schools and colleges was included. Age below 13 and above 18 years was not being included. Out of educational institutes adolescents cannot be the part of the study.

Research Instruments

Demir (2006) created the Critical Thinking Skills Scale (CTSS), which evaluates adolescent' critical thinking skills in six areas: analysis, evaluation, inference, interpretation, explanation, and self-regulation. The items on the scale are separated as follows:

- Analysis: 8 items requiring true or false responses.
- Evaluation: 9 items focusing on judgment and appraisal requiring true or false responses.
- Inference: 8 items for deductive reasoning requiring true or false responses.
- Interpretation: 10 items, evaluated through multiple-choice questions.
- Explanation: 9 items, also assessed through multiple-choice questions.
- Self-Regulation: 12 items on critical self-reflection and adaptability.

A Likert-type scale, ranging from 1 (never) to 3 (always), is used to rate each item of Interpretation, Explanation and Self-Regulation. Demir's study's psychometric qualities showed strong Kuder-Richardson-20 (KR-20) coefficients and Pearson correlation values between 0.70 and 0.86, which suggested good reliability. In order to ensure that it was both culturally relevant and intelligible for adolescents in Faisalabad, the translated and modified version was employed in this study.

1. The forward and backward translation method followed rules (Sousa & Rojjanasrirat, 2011). Process had 5 steps:
2. Two multilingual translators independently translated the survey into Urdu.

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3. A committee of the two translators and the multilingual researcher reached agreed on the final Urdu version.
4. The Urdu version was blindly reverse translated into English by two independent multilingual translators, and the committee procedure and consensus were used again.
5. Two independent native English-speaking specialists compared the English backward translation to the original.

Participants' characteristics were summarized using descriptive statistics. AMOS was used to assess construct validity in CFA. The model's goodness-of-fit was evaluated using chi-square test ($\chi 2$; non-significant). As chi-square is sensitive to sample size, we assessed goodness-of-fit index using $\chi 2/df$ ratio (<3), RMSEA (<0.06), SRMR (<0.08) and CFI >0.95 (Hu & Bentler, 2021; Schreiber et al., 2006). A value of $\alpha \geq 0.7$ was considered satisfactory for Cronbach's alpha coefficient evaluation of internal consistency (Terwee et al., 2007). SPSS v. 25 was used for data analysis.

Results

Table 1 summarizes the demographics information of the 500 participants in the study. Men made up a sizable majority of the participants (72.6%), while women made up 27.4% of the sample. Between 13 and 18 years old, the age distribution was as follows: the largest percentages were at 14 (27.2%) and 17 (18.4%), while the smallest group was at 18 (9.0%). 36.2% of participants were from separate families, whilst the majority (63.8%) were from joint family systems. In terms of educational attainment, the groups in the 9th and 10th grades had the highest percentages (27.4% and 27.2%, respectively), while the group in the 12th grade had the lowest percentage (9.0%). Students from government schools made up the majority of the sample (63.4%), while those from private schools made up 36.6%. Among academic streams, science was studied by more than half (55.4%), followed by computer science (18.0%) and the arts (26.6%). Fewer individuals were the eldest (17.6%) or fourth-born (9.4%), whereas the majority (53.8%) were second-born. There was a wide range of maternal education levels; the largest groups were either graduates (18.4%) or illiterate (18.4%), closely followed by matriculated (18.2%). Only 9.6% of fathers were illiterate, although a larger percentage were intermediate (27.6%) and graduate (27.2%) educated. When asked how many siblings they have, the majority of participants (63.1%) had three, while fewer had two (8.6%) or five (9.4%).

Table 1: Demographic Data of Participants (*N=500*)

		Frequency	**Percent**
Gender	Male	363	72.6%
	Female	137	27.4%
Age	13 Year	47	9.4%
	14 Year	136	27.2%
	15 Year	89	17.8%

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	16 Year	91	18.2%
	17 Year	92	18.4%
	18 Year	45	9.0%
Family System	Joint	319	63.8%
	Separate	181	36.2%
Class Level	8th	90	18.0%
	9th	137	27.4%
	10th	136	27.2%
	11th	92	18.4%
	12th	45	9.0%
School Type	Government	317	63.4%
	Private	183	36.6%
Subject	Science	277	55.4%
	Arts	133	26.6%
	Computer	90	18.0%
Birth Order	1	88	17.6%
	2	269	53.8%
	3	96	19.2%
	4	47	9.4%
Mother Education	Illiterate	92	18.4%
	Primary	88	17.6%
	Elementary	48	9.6%
	Matric	91	18.2%
	Intermediate	89	17.8%
	Graduate	92	18.4%
Father Education	Illiterate	48	9.6%
	Primary	45	9.0%
	Elementary	90	18.0%
	Matric	43	8.6%
	Intermediate	138	27.6%
	Graduate	136	27.2%
No. of Siblings	2	43	8.6%
	3	315	63.0%
	4	95	19.0%
	5	47	9.4%

Descriptive statistics and correlations for critical thinking subscales—analysis,

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evaluation, inference, interpretation, explanation, and self-regulation—are shown in Table 2. The standard deviations of the mean scores for these subscales showed moderate variety, ranging from 1.25 (Inference) to 2.66 (Self-Regulation). Significant relationships between a number of dimensions were found. Analysis, for example, had a negative correlation with both Evaluation (-.697, $p < 0.01$) and Inference (-.489, $p < 0.01$), indicating that Analysis declines when scores in these categories rise. However, there was a significant positive connection between evaluation and inference (.767, $p < 0.01$). Although the correlations between Interpretation and other dimensions were less, it did exhibit a minor negative link with both Self-Regulation (-.110, $p < 0.05$) and Explanation (-.201, $p < 0.01$). A very strong positive correlation (.980, $p < 0.01$) was found between explanation and self-regulation, suggesting a close relationship between these aspects. The reliability analysis showed that the internal consistency of the all subscale was acceptable, with a Cronbach's Alpha of 0.722.

Table 2: Descriptive Statistics and Correlation (*N=500*)

	(1)	(2)	(3)	(4)	(5)	(6)	Mean	SD	Cronbach's Alpha
Analysis (1)	1						1.29	.150	0.722
Evaluation (2)	-.697**	1					1.27	.180	
Inference (3)	-.489**	.767**	1				1.25	.132	
Interpretation (4)	-.049	.024	.035	1			2.63	.290	
Explanation (5)	.048	.022	.019	-.201**	1		2.64	.354	
Self-Regulation (6)	.048	.024	.017	-.110*	.980**	1	2.66	.289	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

In order to investigate the underlying factor structure of the critical thinking dimensions—analysis, evaluation, inference, interpretation, explanation, and self-regulation—an Exploratory Factor Analysis (EFA) was performed. The results are shown in Table 3. According to the EFA results, the first two components—analysis and evaluation—account for 38.545% and 33.845% of the variance, respectively. A further 15.914% of the variance is explained by inference, increasing the total amount of variance explained to more than 88%. With their low contributions, the remaining dimensions—Interpretation (8.521%), Explanation (2.920%), and Self-Regulation (0.255%)—may not be heavily loaded onto the principal components.
For the majority of dimensions, extraction values demonstrate strong

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communalities, suggesting that the factors account for a sizable amount of the variance in these variables. Interestingly, the greatest extraction values are found for Explanation (.982) and Self-Regulation (.956), indicating strong alignment with the components that were identified. Interpretation, on the other hand, has the lowest extraction value (.093), suggesting that it is not well represented in the principal components. A statistically significant EFA (χ^2 = 2527.24, df = 15, p =.000) confirmed that the factor structure was adequate. The critical thinking scale's main dimensions for explaining variance are analysis, evaluation, and inference; interpretation, explanation, and self-regulation play a smaller role.

Table 3: Exploratory Factor Analysis (EFA)

	Total	% of Variance	Extraction	χ2	df	Sig.
Analysis	2.313	38.545	.682	2527.24	15	.000
Evaluation	2.031	33.845	.889			
Inference	.955	15.914	.741			
Interpretation	.511	8.521	.093			
Explanation	.175	2.920	.982			
Self-Regulation	.015	.255	.956			

All the values for estimated parameters for the model were statistically significant in all cases ($p < .001$), consistent with what was expected. None of the variances or correlations revealed values considered to be unsuitable to the extent that the proposal would be invalidated. Therefore, the modification indices recommended that the fit would be better when the residuals between items evaluation and analysis, inference and evaluation, interpretation and analysis, explanation and interpretation, self-regulation and interpretation were correlated (figure 1).

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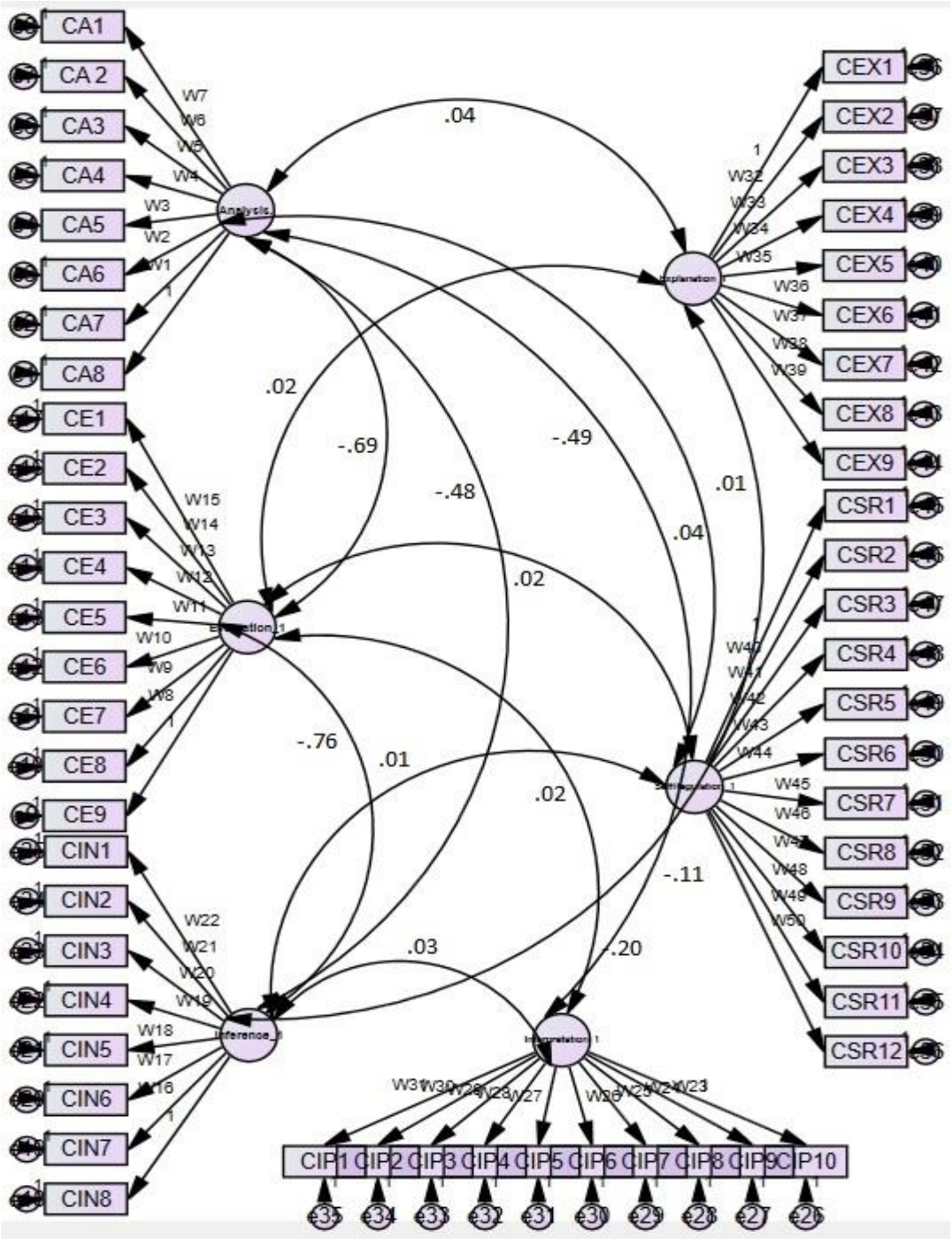

Figure 1: Confirmatory Factor Analysis

The results of the Confirmatory Factor Analysis (CFA) are presented in Table 4. For the majority of dimensions, the χ^2/df ratio shows a satisfactory model fit; values less than 3 indicate a good match. Using this criterion, Analysis (1.69), Inference (1.46), and Interpretation (1.79) show good model fit. However, the

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evaluation indicates poor fit because the χ^2/df ratio (3.07) is higher than the permitted threshold. The CFI values also vary by dimension; with a CFI of 0.97, Inference gets a good fit, although Analysis (0.88) and Interpretation (0.89) are near the acceptable threshold. Weaker model fit is indicated by explanation (0.79) and evaluation (0.84) falling below the suggested value of 0.90. The overall results are also supported by RMSEA values. Based on RMSEA values less than 0.08, dimensions like Inference (0.051) and Interpretation (0.071) show good match. Notably, Evaluation exhibits a larger RMSEA (0.127), indicating a poor fit, but Explanation (0.016) and Self-Regulation (0.011) show unusually strong fits.

Table 4: CFA - Model Fit Indices

	χ^2	χ^2 / df ratio	CFI*	RMSEA*	Fit / No Fit
Analysis	197.6**	1.69	0.88	0.068	Fit
Evaluation	194.6**	3.07	0.84	0.127	No Fit
Inference	49.78***	1.46	0.97	0.051	Fit
Interpretation	199.6**	1.79	0.89	0.071	Fit
Explanation	172.4**	2.91	0.79	0.016	Fit
Self-Regulation	248.2**	2.83	0.85	0.011	Fit

*CFI-Comparative Fit Index, *RMSEA-Root Mean Square Error Approximation
** Significant p= <.000 ***Sig p= <.05

The majority of the students in the sample are male (72.6%), which is consistent with the gender distributions found in educational research in many areas, including Pakistan (Khan & Iqbal, 2016). The majority of participants are between the ages of 14 and 17, which is reflective of the normal adolescent population in secondary schools. Since adolescents are at a vital juncture in their cognitive and emotional development, this aligns with the age group that critical thinking research focusses on (Kuhn, 2015). According to data on family systems and school types, the majority of kids attend government schools (63.4%) and are from joint families (63.8%), which may be a reflection of sociocultural factors that affect learning habits and access to learning materials (Khan, 2018). These demographic specifics are crucial because they put the sample in perspective and give background information on how cultural variables may influence the development of critical thinking abilities.

Exploratory Factor Analysis (EFA) results are consistent with previous research that indicates critical thinking is a multifaceted concept, and these three abilities are frequently regarded as the cornerstones of reasoning and problem-solving (Facione, 2011). In particular, analysis and evaluation are closely related since both require the capacity to critically evaluate information, whereas inference necessitates the drawing of conclusions supported by evidence. According to Halpern (2014), the comparatively small contributions of the remaining dimensions—interpretation, explanation, and self-regulation—indicate that these abilities may not be as important in the way that adolescents are currently taught

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or evaluated in regard to critical thinking. This could point to a discrepancy in the curriculum's emphasis on particular aspects of critical thinking.

Confirmatory Factor Analysis (CFA) provide further support for the EFA findings, with several dimensions displaying good model fit indices, particularly Inference, Interpretation, and Self-Regulation. Evaluation's poor fit on a number of indices, however, raises the possibility that it may not be measuring the intended outcome as well as other dimensions. This is consistent with earlier studies that indicated difficulties in creating accurate and trustworthy assessment instruments for specific facets of critical thinking, such evaluation (Ennis, 2011). Evaluation's comparatively poor fit may be the result of unclear conceptualization or differentiation from other cognitive processes like analysis or inference. By creating more specialized objects or employing different techniques to evaluate evaluation skills, future research could concentrate on honing this dimension.

The Self-Regulation and Explanation dimensions in Table 2 have substantial correlations ($r = .980$, $p < 0.01$), suggesting that they are closely related and might not be sufficiently different to merit evaluation separately. Given that research has demonstrated that self-regulation in critical thinking entails monitoring and modifying one's thinking strategies, which frequently include articulating one's thoughts clearly, this finding implies that self-regulation may be heavily reliant on the capacity to explain one's reasoning or cognitive processes (Zimmerman, 2002). These high correlations make one wonder if the critical thinking scale could be improved to more clearly distinguish between these constructs or if integrating these dimensions into a more comprehensive self-regulation factor would produce more significant findings.

The scale has sufficient internal consistency, according to the Cronbach's Alpha values, which show the scale's overall dependability (the Analysis subscale has an acceptable score of 0.722). Nonetheless, several components (like explanation) showed lower values, suggesting that some parts of the critical thinking scale should use revision to increase their psychometric reliability (Tavakol & Dennick, 2011). These results imply that although the scale is usually helpful in evaluating adolescents' critical thinking, more psychometric testing and improvement are required, especially to strengthen the weaker characteristics.

Conclusion

The findings shed important light on the Critical Thinking Scale's psychometric qualities for teenagers. With special strengths in the areas of analysis, evaluation, and inference, the scale has shown satisfactory reliability and validity overall in evaluating critical thinking constructs. The sample's demographics were typical of secondary school-aged adolescents, enabling a contextually appropriate evaluation of critical thinking abilities. The multifaceted nature of critical thinking as a cognitive process was confirmed by the Exploratory Factor Analysis (EFA), which showed that the main components influencing teenagers' critical thinking abilities are analysis, evaluation, and inference. Although several dimensions, like evaluation, displayed unsatisfactory fit indices, highlighting opportunities for development, the Confirmatory Factor Analysis (CFA) provided additional support

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for these findings. Although the scale offers useful data, it also highlights several shortcomings, especially with regard to how the Evaluation dimension is conceptualized and measured.

Self-Regulation and Explanation strongly correlate, it's possible that these concepts overlap more than first thought. Because of this overlap, it is unclear if these aspects belong in a larger category of self-regulated thought or should be considered distinct categories. Furthermore, the scale's comparatively poorer performance in other areas, like evaluation, suggests that its conceptual clarity and design need to be improved. The study shows that the Critical Thinking Scale is a helpful instrument for evaluating teenagers' critical thinking skills in secondary school, despite these difficulties. It lays the groundwork for future investigation and improvement by revealing how teenagers use critical thinking and where teaching methods might be strengthened. Despite being generally good, the scale's psychometric qualities emphasize the significance of ongoing testing and validation in various educational contexts to guarantee its applicability across a range of demographics and environments.

Recommendation

1. The CFA analysis revealed lower fit indices for the Evaluation subscale. It is advised that the items in this dimension be reviewed and improved to better represent the idea of critical evaluation in order to increase its validity and reliability. To guarantee better conformity with adolescents' cognitive processes, this could entail more context-specific examples or clearer item wording.
2. Considering the strong relationship between explanation and self-regulation, it might be advantageous to combine these dimensions into a single factor or to reinterpret them in order to eliminate duplication. The scale's overall conceptual clarity and psychometric qualities would be improved by a more precise definition of these constructs.
3. Future research should take cross-cultural validity of the scale into consideration, as the study sample was predominantly from Pakistan. To make sure the items are culturally appropriate and representative of how teenagers use critical thinking in various cultural contexts, adjustments may be required.
4. Future research should explore about employing a longitudinal design and a more varied sample to evaluate how teenagers' critical thinking abilities change over time in order to better validate the scale. The scale's usefulness in different educational settings and geographical areas would be ensured by a wider demographic representation.

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