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Pre-service teachers' competencies to develop computational thinking: A Portuguese tool to analyse Computational Thinking

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Abstract
Computational thinking (CT) is an essential mathematical skill for problem-solving and students' future lives. It is integrated into the educational curricula of several countries, including Portugal. Therefore, pre-service teachers (PST) must possess didactic knowledge to effectively develop CT in students. The aim of this study encompassed three main objectives: translating and adapting the computational thinking scale into Portuguese (study 1), validating the scale (study 2), and assessing the perceived levels of CT competencies among PST in Portuguese university students while examining differences between undergraduate and master's level PST (study 3). The sample consisted of study 1 with 43 participants and study 2 and study 3 with 382 participants. In study 1, temporal stability was assessed indicating strong stability. The internal consistency showed good homogeneity of the items. The exploratory factor analysis revealed consistency with the structure of the original scale. In conclusion, the Portuguese version of the CT scale demonstrates adequate psychometric properties, proving valid and reliable for assessing CT in university students. Additionally, significant differences were observed between undergraduate and master's degree students, underscoring the importance of tailored training programs to meet the specific needs of undergraduate students.

Keywords: pre-service teachers training, computational thinking, questionnaire validation, computational thinking scale

INTRODUCTION

The concept of computational thinking (CT) first appeared in the literature by Papert (1980), who referred to it as the mental ability to think like a computer. However, it was Wing (2006) who gave impetus to research into CT by emphasizing the importance of developing this ability in children (Knie et al., 2022; Menolli & Neto, 2022). Although this topic is not new to the scientific community, several gaps remain regarding CT, in particular the existence of varied definitions for CT skills (Ausiku & Matthee, 2021; Román-González et al., 2018) and, as a result, the diversity of instruments used to analyze CT skill levels based on these differing definitions (Shute et al., 2017). CT is often associated with computer science as a necessary skill for using technology, which is increasingly present in the 21st century (Kılıç et al., 2021; Li et al., 2024b). However, several authors argue that it is not necessary to integrate technology to promote the development of CT (El-Hamamsy et al., 2021; Espadeiro, 2021; Haşlaman et al., 2024), deriving this term from the fact that CT is based on the fundamental principles of computing. Although its definition is unclear, there is a consensus in the

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Contribution to the literature

- This article presents a CT scale translated and adapted into Portuguese, which allows us to access the perception of the levels of CT competencies of Portuguese pre-service teachers (PST) in initial teacher training.
- The article also studies and presents the possibility that there are differences in the perception of the levels of CT competencies of PST studying for a bachelor's degree compared to PST studying for a master's degree.
- This provides a starting point for the training programs to be developed, highlighting the importance of investigating the differences between the different teacher training cycles to establish training programs suited to the specific needs of PST.

scientific community that CT is an essential skill in the problem-solving process, making its development indispensable for students at all levels of schooling (Çoban & Korkmaz, 2021; Sırakaya et al., 2020).

Wing, in 2006 suggested that computer science teachers should create a course to expose students, even before they enter university, to "ways to think like a computer scientist" (p. 35). Back in 2013, Grover and Pea (2013) discussed whether CT should be taught as a general subject, a subject within a specific discipline, or as a multidisciplinary subject. They highlighted that computing skills will be essential for all students' futures, regardless of whether they pursue computer science. Shute et al. (2017) point out the importance of having a valid and reliable tool that can be used to analyze CT skills, regardless of the subject in which it is integrated. The same authors also highlight the difficulty of analyzing CT competence levels to determine not only the success of interventions but also the progress of students throughout the intervention, identifying this as a gap in CT research.

In 2024, how to analyze CT development continues to be pointed out as a gap in this area, as a result of the lack of a consensual definition for this ability (Espinal et al., 2024; Li et al., 2024a; Rao & Bhagat, 2024).

In Portugal, CT was integrated into the Math curriculum for the first time in 2021 (Ministério da Educação, 2021), being considered a mathematical skill to be developed from the first year of primary school.

Several other countries, such as Thailand (Pewkam & Chamrat, 2022), Ireland (Butler & Leahy, 2021), New Zealand (Macann & Carvalho, 2021), and Norway (Kravik et al., 2022), have also recognized the importance of developing this skill in students and have incorporated CT into their educational curricula. However, teachers and PST point to a lack of specific training in the field of CT (Angeli & Giannakos, 2019; Haşlaman et al., 2024; Pewkam & Chamrat, 2022), which results in a lack of didactic knowledge to integrate this skill into their practice, leading to low self-efficacy, interest, and confidence among teachers (Kaya et al., 2019; Li et al., 2024b). By training PST on how to integrate CT development into their practice, it is possible to bridge this knowledge gap (Sun et al., 2023). This approach increases the likelihood of reaching all students at the beginning of their schooling, not just those in schools that can offer extracurricular activities involving CT (Butler & Leahy, 2021).

The lack of studies that rigorously evaluate training experiences and present valid evaluation tools and strategies is one of the significant gaps identified in published research (Da Cruz Alves et al., 2019; Ling et al., 2017; Ortuño Meseguer & Serrano, 2024). The effectiveness of training given to PST depends on assessing their perception of their levels of CT competencies before the training begins so that they can include the development of CT in the planning of future practices (Ortuño Meseguer & Serrano, 2024). It is also necessary to assess PST' perceptions of their level of CT competencies after the training program to evaluate the training implemented (Li et al., 2024b).

Therefore, it is considered necessary to have an instrument that can be used at different times during the intervention to assess whether the training implemented had an impact on the perception of PST' levels of CT competencies (Román-González et al., 2017). Given the lack of validated scales for the Portuguese population, we decided to translate the computational thinking scale (CTS) by Korkmaz et al. (2017) and apply it to PST in initial teacher training in Portugal, both undergraduate and master's, with a view to validating it in Portuguese.

In a study carried out by Çakir et al. (2021), where the CTS was applied, it was revealed that the competencies among PST in their final year of initial teacher training at a university in Turkey were significantly higher than those of PST in their first year. The existence of statistically significant differences between different years of schooling may require training programs to be adapted to meet the specific needs of the groups being trained (Avcı & Deniz, 2022). In this sense, and in line with Dong et al. (2024), there is a need for studies that analyze the differences between the CT skills among participants at different levels of initial teacher training.

In Portugal, initial teacher training involves completing both two degrees: a bachelor's degree and a master's degree, i.e., to become a teacher, it is required to complete a master's degree. Thus, the following question emerges: Are there statistically significant differences between the perceived levels of CT competencies of PST studying for a bachelor's degree and PST studying for a master's degree?

This study aims to fill the gap in Portugal regarding the tools for analyzing the perception of levels of CT competencies and thus contribute to the development of more precise and appropriate training for PST. The main objectives of this work are to translate, adapt, and validate the CTS (Korkmaz et al., 2017) into Portuguese for PST in initial teacher training. This aims to assess the perception of CT competencies among Portuguese PST. Additionally, the study seeks to investigate potential differences in the perception of CT competencies between PST pursuing bachelor's degrees and those pursuing master's degrees. This research aims to contribute to understanding the development and assessment of CT competencies among PST in Portugal.

MATERIAL AND METHODS

Study Design

In order to achieve the proposed objectives, three studies were devised:

(1) study 1 aimed to translate and adapt the CTS into Portuguese,

(2) study 2 aimed to validate and verify the psychometric characteristics of the Portuguese version of the CTS, and

(3) study 3 aimed to compare the perceived levels of CT competencies between PST studying for a bachelor's degree and those studying for a master's degree.

Participants

Study 1

To conduct the test-retest and assess the scale's reliability, a sample of 43 participants from two universities in mainland Portugal completed the scale during the 2022/2023 academic year. The participants had an average age of 21.67 years (standard deviation [SD] = 5.181), ranging from 18 to 44 years old, and all were female. It is important to note that 76.7% of the participants were pursuing a bachelor's degree in Basic Education, 14% were enrolled in a master's degree program in "preschool education and primary school teaching", and 9.3% were pursuing a master's degree in "primary school teaching and 2nd grade school teaching in mathematics and experimental sciences."

Study 2 and study 3

The sample for these studies comprised 382 participants from 7 universities in mainland Portugal who completed the scale during the 2022/2023 academic year. The participants had an average age of 22.60 years (SD = 6.271), ranging from 18 to 54 years old. Among them, 359 identified as female, 19 as male, and four chose not to disclose their gender. Regarding the academic distribution, 63.4% of the participants were pursuing a bachelor's degree in basic education, 6% were enrolled in a master's degree program in "preschool education", 17% were pursuing a master's degree in "preschool education and primary school teaching", 8.6% were enrolled in a master's degree program in "primary school teaching and 2nd grade school teaching in mathematics and experimental sciences", and 5% were pursuing a master's degree in "primary school teaching and 2nd grade school teaching in history and geography of Portugal."

Table 1. Dimensions and corresponding items of the computational thinking scale

Dimensions	Items
Creativity	1, 2, 3, 4, 5, 6, 7, & 8
Algorithmic thinking	9, 10, 11, 12, 13, & 14
Cooperativity	15, 16, 17, & 18
Critical thinking	19, 20, 21, 22, & 23
Problem-solving	24, 25, 26, 27, 28, & 29

Instruments

The CTS (**Appendix A**), developed and validated by Korkmaz et al. (2017), was utilized to assess the perception of PST' levels of CT competencies. The scale consists of 29 items that evaluate five dimensions: creativity (item 1 to item 8), algorithmic thinking (item 9 to item 14), cooperativity (item 15 to item 18), critical thinking (item 19 to item 23), and problem-solving (item 24 to item 29) (**Table 1**), rated on a five-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = generally, and 5 = always). The items had good and stable internal consistency (creativity $\alpha = 0.843$; algorithmic thinking $\alpha = 0.869$; cooperativity $\alpha = 0.865$; critical thinking $\alpha = 0.784$; problem-solving $\alpha = 0.727$) and $\alpha = 0.822$ for the total scale.

A demographic questionnaire was created in order to ascertain the characteristics of the participants involved in the studies.

Ethical Statement

This study strictly followed the ethical principles established in the Declaration of Helsinki, ensuring the protection of the rights and well-being of the participants. This study was previously approved by the Ethics Committee of the Polytechnic University of Coimbra (101_CEIPC/2022, approved on 24 June 2022), which guarantees that all procedures complied with ethical regulations. All participants gave their informed consent before taking part in the study, with full knowledge of the aim of the study, the voluntary nature of their participation and their right to withdraw at any time, without any penalty. The confidentiality of the data was ensured, with it being collected and stored securely in accordance with the general data protection regulation (regulation [EU] 2016/679 of the European Parliament and of the Council of 27 April). These procedures guarantee the transparency and integrity of the study, respecting the highest ethical and legal standards.

Procedures

Study 1

Adaptation of the scale: After confirming the suitability of the selected scale for the intended context through a detailed analysis of the original version, we proceeded with translating and adapting the scale into Portuguese. The original instrument was translated by a professional translator who ensured that the meaning of each item was accurately conveyed in the Portuguese version. Subsequently, two researchers reviewed each item to refine the language and ensure clarity for the Portuguese population.

A second native English translator, who was not aware of the original version, conducted a back-translation of the Portuguese text into English. Subsequently, the back-translation was compared with the source text to identify and rectify any inconsistencies.

In order to ascertain the content validity, the two versions were then subjected to examination by two researchers who were acknowledged experts in the specific field (theoretical and practical). They evaluated the differences and made the necessary adjustments based on their review (Balbinotti, 2005; Hernandez-Nieto, 2002).

Ultimately, the definitive wording for the Portuguese items was established, the integrity of the adapted instrument was confirmed, and the final Portuguese version of the CTS scale was obtained.

This process ensured that the Portuguese version of the scale was faithful to the original instrument and appropriate for the specific cultural context (see **Appendix B**).

Data collection for the three studies described was conducted individually and online, utilizing a link that provided access to the scale via Google Forms (please see supplementary materials).

Scale stability: To assess the scale's temporal stability (reliability), the intraclass correlation coefficient (ICC) was calculated for the test and retest results (study 1). This analysis was conducted between two administrations of the scale: moment 1 (M1) and moment 2 (M2), with an interval of 4 weeks. The study involved a sample of 43 participants, with an average age of 21.67 years (SD = 5.181), ranging from 18 to 44 years old.

Internal consistency of the scale: To analyze the reliability and internal consistency of the scale, Cronbach's alpha coefficient was calculated for the entire scale and for each dimension separately during the test and retest phases.

Study 2

Internal consistency of the scale: The reliability and internal consistency of the scale were analyzed similarly to study 1, using Cronbach's alpha coefficient for both the entire scale and each dimension of the scale individually.

Scale validation: Exploratory factor analysis was conducted using the principal component analysis method, applying varimax rotation with Kaiser normalization and excluding items with factor loadings below 0.4. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (BET) were calculated to assess the construct validity of the scale and determine the suitability of the data for factor analysis (Field, 2018; Marôco, 2021).

Statistical Analysis and Data Reliability Across Studies

In study 1, the degree of confidence in the collected data, regarding the scale application, was assessed through the internal consistency measured using Cronbach's alpha coefficient (Pallant, 2020; Pestana & Gageiro, 2014). The classification of alpha coefficients was, as follows: very good ($\alpha \geq 0.9$); good ($0.8 \leq \alpha < 0.9$); reasonable ($0.7 \leq \alpha < 0.8$); weak ($0.6 \leq \alpha < 0.7$); unacceptable ($\alpha < 0.6$). To assess the temporal stability of the scale, i.e., the consistency of results obtained at different times when the instrument was applied, the ICC was calculated for the test and retest results. Based on the 95% confidence interval of the ICC estimate, values less than 0.5 indicate poor reliability, 0.5 to 0.75 suggest moderate reliability, 0.75 to 0.9 suggest good reliability and values above 0.9 indicate excellent reliability (Koo & Li, 2016). To compare the participants' perceived levels of CT competencies between the test and retest, the Student's t-test for paired samples was employed after validating its assumptions (Field, 2018; Marôco, 2021). This test makes it possible to assess whether there are statistically significant differences between the means of the two measurements (test and retest) and is suitable for situations in which the same samples are assessed at different times. The normality assumption of each dependent variable was assessed using the Kolmogorov-Smirnov test. In cases where the normality assumption was not verified, the central limit theorem was applied (Marôco, 2021; Pestana & Gageiro, 2014). This theorem ensures that with sufficiently large samples ($n \geq 30$), the sample distribution of the mean tends to be normal, allowing the use of the t-test even in the absence of normality in the data. Therefore, the assumption of normality was made (Marôco, 2021; Pestana & Gageiro, 2014). The effect size value for the paired-samples t-test is calculated using Cohen's d, and the effect size is classified as follows (Marôco, 2021): small (d ≤0.2), medium (0.2 < d ≤ 0.5), large (0.5 < d ≤ 0.8), and very large (d > 0.8).

In study 2, the reliability of the collected data was assessed using Cronbach's alpha coefficient, following a similar approach to study 1. Additionally, the KMO measure of sampling adequacy and BET were calculated in order to determine the construct validity of the scale and assess the suitability for factor analysis (Fávero et al., 2009). The KMO test assesses the adequacy of the sample, and values above 0.70 are required for the sample to be considered suitable for factor analysis. The BET tests the hypothesis that the correlation matrix between variables is significantly different from the identity matrix, i.e., it checks for interdependence between variables. Statistical significance (p < 0.05) is required to proceed with factor analysis (Eroğlu, 2008). The Kaiser criterion was applied, where only factors with eigenvalues greater than 1.0 are considered significant. This ensures that each factor explains a sufficient percentage of the total variance.

In study 3, to compare the perception of levels of CT competencies between participants pursuing bachelor's and master's degrees across the entire scale and each dimension (creativity, algorithmic thinking, cooperativity, critical thinking, and problem-solving), the student's t-test for independent samples was utilized. Prior to conducting the t-test, the normality assumption was validated (Marôco, 2021; Pallant, 2020). This test makes it possible to check whether there are statistically significant differences between the perceptions of CT competence of the two levels of training, by comparing the means between the two groups. The effect size for the t-test of independent samples was calculated using Cohen's d, and its classification follows a similar approach to that of the paired t-test (Marôco 2021), as described in study 1.

All statistical analyses at a 5% significance level (p < 0.05) for studies 1, 2, and 3 were carried out using the IBM statistical package for the social sciences (version 28, IBM USA).

RESULTS

Within the framework of the reliability and validity of the CTS (internal consistency, test-retest reliability, factor analysis), and comparisons across participant groups have been examined.

Analysis of Study 1

Internal consistency

In order to assess the scale's reliability and internal consistency, Cronbach's alpha coefficient was calculated for both the total scale and each of its dimensions, in both the test and retest stages. The 29-item scale exhibited a total Cronbach's alpha coefficient (DTOTAL) of 0.899 for M1 and 0.932 for M2, showing consistent values across both test (M1) and retest (M2) administrations. The Cronbach's alpha coefficients by dimension were, as follows: creativity (DCRI) α = 0.784 vs α = 0.815; algorithmic thinking (DPAL) α = 0.790 vs α = 0.859; cooperativity (DCOO) α = 0.852 vs α = 0.906; critical thinking (DPCR) α = 0.777 vs α = 0.889; problem-solving (DRPR) α = 0.805 vs α = 0.893 (**Table 2**).

Table 2. Cronbach's alpha coefficients in M1 and M2

Factors	Items	CA	
		M1	M2
Creativity	1, 2, 3, 4, 5, 6, 7, & 8	0.784	0.815
Algorithmic thinking	9, 10, 11, 12, 13, & 14	0.790	0.859
Cooperativity	15, 16, 17, & 18	0.852	0.906
Critical thinking	19, 20, 21, 22, & 23	0.777	0.889
Problem-solving	24, 25, 26, 27, 28, & 29	0.805	0.893
Total scale	1 to 29	0.899	0.932

Note. CA: Cronbach's alpha

Test-retest reliability

The consistency of the results obtained at the two moments of application of the scale, which guarantees the temporal stability of this instrument, was verified using the ICC. The ICC for mean measures was 0.705 (F [42, 42] = 3.339; p = 0.001), which indicated moderate reliability, which ensures that the scale offers acceptable stability over time (Koo & Li, 2016). It can be seen that there were no statistical differences between the total means in DTOTAL_M1 (mean [M] = 107.26; SD = 11.03) and DTOTAL_M2 (M = 106.77; SD = 14.18), t = 0.263, p = 0.794. The effect size was small (d = 0.040), suggesting that the variation observed between the two measurements is statistically insignificant (**Table 3**).

Table 3. Descriptive statistics and comparison between M1 and M2

	M	SD	t	p	d	ES
DTOTAL_M1	107.256	11.026	0.263	0.794	0.040	Small
DTOTAL_M2	106.767	14.182				

Note. ES: Effect size

Analysis of Study 2

Internal consistency of the scale

Similar to study 1, in order to check the scale's reliability and internal consistency, Cronbach's alpha coefficient was calculated for both the total scale and each of its dimensions. The 29-item scale demonstrated a total Cronbach's alpha coefficient of 0.888, which did not improve with the removal of any item. The Cronbach's alpha coefficients by dimension were, as follows: creativity (α = 0.780), algorithmic thinking (α = 0.843), cooperativity (α = 0.878), critical thinking (α = 0.824), and problem-solving (α = 0.808). These results indicate good internal consistency of the scale (Pestana & Gageiro, 2014) (see **Table 4**).

Table 4. Internal consistency of the total scale and by dimension

	Items	Cronbach's alpha	
		Korkmaz et al. (2017)	Present study
Creativity	1, 2, 3, 4, 5, 6, 7, & 8	0.843	0.780
Algorithmic thinking	9, 10, 11, 12, 13, & 14	0.869	0.843
Cooperativity	15, 16, 17, & 18	0.865	0.878
Critical thinking	19, 20, 21, 22, & 23	0.784	0.824
Problem-solving	24, 25, 26, 27, 28, & 29	0.727	0.808
Total scale	1 to 29	0.822	0.888

Table 5. KMO & BET

Test		Result
KMO measure of sampling adequacy		0.873
BET	Approximate Chi-squared	4,946.383
	gl	406
	p	0.001

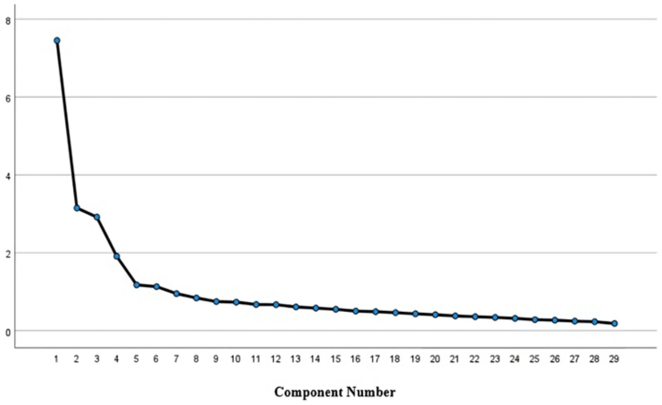

Figure 1. Scree plot showing eigenvalues and the point of factor retention based on the elbow method (Source: Authors' own elaboration, using IBM SPSS Statistics v.28)

Exploratory factor analysis

In order to determine the construct validity of the scale and understand whether or not factor analysis could be carried out, the KMO measure of sampling adequacy and BET were calculated. The results indicated that the data set is at the appropriate level for conducting factor analysis (KMO = 0.873) and BET ($p < 0.5$) (unit correlation matrix), at the 0.05 significance level (Eroğlu, 2008) (**Table 5**). Regarding communalities, practically all the items explained at least half the variance of the original variables.

Using the Kaiser criterion (eigenvalues > 1.0), 6 factors representing 61% of the total variance were obtained. Considering the existence of 6 factors, the scree plot was analyzed and, considering the start of the elbow of the curve, it was found that there were 5 factors (**Figure 1**). Thus, the extraction was forced to 5 factors that explained 57.26% of the total variance (**Table 6**).

Based on the tetra-factor solution obtained and the analysis of item loadings (> 0.4) within each factor, the items were distributed across five factors accordingly

Table 6. Total variance explained with 5 factors

Component	Initial eigenvalues			ESSL			RSSL		
	Total	Var%	CP%	Total	Var%	CP%	Total	V%	CP%
1	7.452	25.698	25.698	7.452	25.698	25.698	3.570	12.312	12.312
2	3.150	10.863	36.560	3.150	10.863	36.560	3.435	11.845	24.157
3	2.918	10.062	46.622	2.918	10.062	46.622	3.430	11.829	35.985
4	1.910	6.586	53.208	1.910	6.586	53.208	3.181	10.968	46.953
5	1.176	4.054	57.263	1.176	4.054	57.263	2.990	10.310	57.263
6	1.132	3.902	61.165						
7	0.951	3.281	64.446						
8	0.841	2.899	67.345						
9	0.748	2.579	69.924						
10	0.733	2.529	72.454						
11	0.673	2.319	74.773						
12	0.668	2.305	77.078						
13	0.610	2.104	79.182						
14	0.579	1.997	81.179						
15	0.549	1.894	83.073						
16	0.503	1.736	84.808						
17	0.488	1.681	86.490						
18	0.463	1.596	88.086						
19	0.434	1.496	89.582						
20	0.410	1.414	90.996						
21	0.379	1.306	92.302						
22	0.359	1.238	93.540						
23	0.341	1.178	94.717						
24	0.318	1.095	95.812						
25	0.283	0.977	96.789						

Table 6 (Continued). Total variance explained with 5 factors

Component	Initial eigenvalues			ESSL			RSSL		
	Total	Var%	CP%	Total	Var%	CP%	Total	V%	CP%
26	0.269	0.929	97.718						
27	0.245	0.846	98.564						
28	0.231	0.798	99.362						
29	0.185	0.638	100.000						

Note. Extraction method: PCA; C: Component; ESSL: Extraction sums of squared loadings; RSSL: Rotation sums of squared loading; CP%: Cumulative %; & V%: % of variance

Table 7. Descriptive statistics and comparison between bachelor's and master's degrees

	Degree	Mean	SD	t	p	d	Effect size
DCRI	Bachelor	31.711	3.998	-1.071	0.285	0.114	Small
	Master	32.157	3.801				
DPAL	Bachelor	19.388	3.705	-2.438	0.015	0.259	Medium
	Master	20.329	3.502				
DCOO	Bachelor	16.091	2.869	-3.202	0.001	0.340	Medium
	Master	17.050	2.736				
DPCR	Bachelor	17.607	3.141	-1.191	0.234	0.126	Small
	Master	18.007	3.195				
DRPR	Bachelor	20.417	3.614	-2.013	0.045	0.214	Medium
	Master	21.164	3.278				
DTOTAL	Bachelor	105.215	11.056	-2.874	0.004	0.305	Medium
	Master	108.707	12.082				

Note. DCRI: Creativity; DPAL: Algorithmic thinking; DCOO: Cooperativity; DPCR: Critical thinking; & DRPR: Problem-solving

with the original version of the scale, as follows: factor 1 (9, 10, 11, 12, 13,14), factor 2 (15, 16, 17, 18), factor 3 (1, 2, 3, 4, 5, 6, 7, 8), factor 4 (24, 25, 26, 27, 28, 29), and factor 5 (19, 20, 21, 22, 23).

Perception of Levels of CT Competencies

To determine whether there were statistically significant differences between the perceptions of CT competence at the two levels of training, the student's t-test for independent samples was applied. The results of the student's t-test for independent samples to compare the perception of levels of CT competencies between bachelor's and master's degree participants, for the entire scale and each of the dimensions, showed that no significant differences were observed for the DCRI ($t = -1.071$, $p = 0.285$, $d = 0.114$) and DPCR ($t = -1.191$, $p = 0.234$, $d = 0.126$) variables. However, for the DPAL ($t = -2.438$, $p = 0.015$, $d = 0.259$), DCOO ($t = -3.202$, $p = 0.001$, $d = 0.340$), DRPR ($t = -2.013$, $p = 0.045$, $d = 0.214$) and DTOTAL ($t = -2.874$, $p = 0.004$, $d = 0.305$), there were statistically significant differences between bachelor's and master's degree participants' perception of levels of CT competencies, all with medium effect sizes (**Table 7**).

DISCUSSION

The aims of this work were to translate, adapt, and validate a scale to analyze the perception of PST' levels of CT competencies. The validation of the CTS began with the translation and adaptation of the original scale into Portuguese. Like the original scale, the translated and validated scale contains 29 items, subdivided into five competencies: creativity, algorithmic thinking, cooperativity, critical thinking, and problem-solving.

The analysis of the scale's reliability, through a test and retest carried out four weeks apart, the ICC = 0.705 indicated moderate reliability (Koo & Li, 2016),. The analysis of the internal consistency using Cronbach's alpha coefficient (0.899 vs. 0.932) revealed good and very good internal consistency, respectively (Pallant, 2020) of the values for each dimension of the scale and for the entire scale, both at M1 and M2 of implementation.

After analyzing the reliability of the scale in study 2, in a sample of 382 participants, we found good internal consistency (Pallant, 2020), both for the total scale (0.888) and its dimensions (ranging from 0.780 to 0.878), which were similar to those of the original validation (0.822 for the total scale and between 0.727 and 0.869 for the dimensions) (Korkmaz et al., 2017). The KMO value for the adequacy of the exploratory factor analysis (0.873), and the chi-square value for BET (4,946.383; $p = 0.001$), demonstrating the feasibility of the exploratory factor analysis. There were also five factors explaining 57.26% of the total variance, similar to the original scale, where the five factors explained 56.12% of the total variance (Korkmaz et al., 2017). Thus, the final five-factor solution proved to be structurally compatible with the original creation study in terms of dimensionality.

Given the above results, it can be concluded that the scale is an appropriate instrument in terms of reliability and validity, addressing one of the gaps identified by Espinal et al. (2024). There is now a validated scale to analyze levels of competence in CT within the context of initial teacher training in Portugal. It is expected that, with the validation of this scale, studies can be conducted on the competencies of PST attending a bachelor's degree, as well as those attending a master's degree, allowing for comparisons between these two levels of initial teacher training in Portugal.

To answer the research question posed, it was found that there are differences in the perceptions of competencies for developing CT between PST studying for a bachelor's degree and those studying for a master's degree. The results showed statistically significant differences (Field, 2018) in some dimensions of the CTS, such as algorithmic thinking (DPAL), cooperativity (DCOO), problem-solving (DRPR), and the overall assessment of the scale (DTOTAL). These differences align with the results of other studies comparing the perceived competencies of teachers with different levels of training (Avcı & Deniz, 2022; Sun et al., 2023), particularly the study conducted by Çakir et al. (2021), who also applied this scale to PST in Turkey and found statistically significant differences in some of the dimensions analyzed, specifically algorithmic thinking and creativity. This indicates that the level of training can influence the perception of PST' levels of CT competencies. By analyzing the results of the application of this scale, potential areas where specific interventions may be necessary can be identified.

Study Limitations

Regarding the limitations of the study, the primary limitation is that there is little theoretical grounding on the subject, more specifically, scientific contributions that relate to the perception of PST' levels of CT competencies at both the bachelor's and master's levels of initial teacher training. The existence of little specific literature in this context makes it difficult to compare the results with other similar investigations. Another potential limitation is that the sample consisted predominantly of female participants. However, it is important to emphasize that this distribution reflects the reality of initial teacher training courses in Portugal, where the majority of students are female. It is therefore considered that the composition of the sample does not distort the results but is in line with the characteristics of the target population. Previous studies have also shown that there are no statistically significant differences in CT skills between men and women (Werner et al., 2012; Yadav et al., 2014), which reinforces that the predominance of women in the sample does not compromise the validity of this study's conclusions.

Additionally, a limitation related to the participants is that the sample only included PST attending bachelor's and master's programs. To enhance the robustness of future studies, it is suggested that the research be replicated with a more diverse sample, including bachelor's, master's, and doctoral students. This would allow for a more comprehensive understanding of whether differences in perceptions of CT competencies become more pronounced depending on the participants' levels of academic training.

Suggestions for Future Studies

To increase the robustness of the results and to allow for generalization, future studies could replicate this study with a sample more representative of the Portuguese population. This sample would allow for verification of whether the results observed in the present study can be generalized to a broader audience, ensuring greater external validity of the findings. However, it should be noted that the primary aim of this study was to validate the instrument, not to generalize the findings to the Portuguese population. Therefore, we did not require a representative sample, only one that was ten times the number of items on the scale and over 300 participants (Nunnally, 1978).

Practical Applications

The statistically significant differences were observed in the perceptions of levels of CT competencies between PST attending bachelor's and master's programs, underscores the importance of conducting studies that analyze the differences in CT competencies among participants at different levels of initial teacher training, as noted by Dong et al. (2024). Particular attention should be paid to the dimensions where these differences were observed: algorithmic thinking, cooperativity, and problem-solving. The integration of specific programs into initial teacher training should be carried out strategically, focusing on developing the dimensions where the largest gaps were identified, namely algorithmic thinking, cooperativity, and problem-solving. Since lower averages were observed in these dimensions among undergraduate students, training programs for this level of education require a more intensive and focused approach. To promote the development of algorithmic thinking, problem-solving tasks involving the definition of logical and sequential steps should be incorporated. Regarding cooperativity, tasks fostering collaborative learning in small groups can be included, encouraging peer collaboration while simultaneously developing the problem-solving dimension.

Given the observed differences, training programs should be tailored to the characteristics of the specific study cycle. For the bachelor's degree, based on the results of this study, the need to develop CT competencies is clear. For the master's degree, in addition to developing these competencies, it is crucial to integrate tasks that promote the development of pedagogical knowledge, especially during internships, to incorporate these competencies into practical teaching experiences.

CONCLUSIONS

The main contribution of this work was to translate, adapt, and validate the CTS into Portuguese since no validated instrument in Portuguese was found in the literature to analyze the perception of PST' levels of competencies in CT during initial teacher training.

This study also made it possible to verify that there are differences in the perception of the levels of certain competencies (DPAL, DCOO, DRPR, and DTOTAL) in CT between PST attending a bachelor's degree and those attending a master's degree. Considering the need to adjust training programs to the specific study cycle in which they will occur, it is essential to have an instrument that allows for the analysis of students' CT competencies, not only at the end of the interventions but also throughout the intervention, so that necessary adjustments can be made. In this way, an instrument is provided to analyze the perceptions of PST' levels of competencies in CT, which could be used in future studies in Portugal. Further studies should be carried out to verify the applicability of the scale in different contexts and samples.

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APPENDIX A: COMPUTATIONAL THINKING SCALE

Table A1. CTS (Korkmaz et al., 2017)

Creativity	1. I like the people who are sure of most of their decisions. 2. I like the people who are realistic and neutral. 3. I believe that I can solve most of the problems I face if I have sufficient amount of time and if I show effort. 4. I have a belief that I can solve the problems possible to occur when I encounter with a new situation. 5. I trust that I can apply the plan while making it to solve a problem of mine. 6. Dreaming causes my most important projects to come to light. 7. I trust my intuitions and feelings of "trueness" and "wrongness" when I approach the solution of a problem. 8. When I encounter with a problem, I stop before proceeding to another subject and think over that problem.
Algorithmic thinking	9. I can immediately establish the equity that will give the solution of a problem. 10. I think that I have a special interest in the mathematical processes. 11. I think that I learn better the instructions made with the help of mathematical symbols and concepts. 12. I believe that I can easily catch the relation between the figures. 13. I can mathematically express the solution ways of the problems I face in the daily life. 14. I can digitize a mathematical problem expressed verbally.
Cooperativity	15. I like experiencing cooperative learning together with my group friends. 16. In the cooperative learning, I think that I attain/will attain more successful results because I am working in a group. 17. I like solving problems related to group project together with my friends in cooperative learning. 18. More ideas occur in cooperative learning.
Critical thinking	19. I am good at preparing regular plans regarding the solution of the complex problems. 20. It is fun to try to solve the complex problems. 21. I am willing to learn challenging things. 22. I am proud of being able to think with a great precision. 23. I make use of a systematic method while comparing the options at my hand and while reaching a decision.
Problem-solving	24. I have problems in the demonstration of the solution of a problem in my mind. 25. I have problems in the issue of where and how I should use the variables such as X and Y in the solution of a problem. 26. I cannot apply the solution ways I plan respectively and gradually. 27. I cannot produce so many options while thinking of the possible solution ways regarding a problem. 28. I cannot develop my own ideas in the environment of cooperative learning. 29. It tires me to try to learn something together with my group friends in cooperative learning.

APPENDIX B: PORTUGUESE VERSION OF THE COMPUTATIONAL THINKING SCALE

Table B1. Portuguese version of the CTS

Criatividade	1. Gosto das pessoas que estão seguras da maior parte das suas decisões. 2. Gosto das pessoas que são realistas e imparciais. 3. Acredito que consigo resolver a maior parte dos problemas com que me deparo se tiver tempo suficiente e se me esforçar. 4. Acredito que consigo resolver os problemas que possam surgir quando me deparo com uma situação nova. 5. Confio que posso aplicar o plano que estou a elaborar para resolver um problema meu. 6. Sonhar faz com que os meus projetos mais importantes venham à tona. 7. Confio nas minhas intuições e nos meus sentimentos de "certo" e "errado" quando me aproximo da solução de um problema. 8. Quando me deparo com um problema, paro antes de passar a outro assunto e reflito sobre esse problema.
Pensamento algorítmico	9. Posso estabelecer imediatamente a equidade que dará a solução de um problema. 10. Penso que tenho um interesse especial pelos processos matemáticos. 11. Penso que aprendo melhor as instruções dadas com a ajuda de símbolos e conceitos matemáticos. 12. Penso que consigo captar facilmente a relação entre as figuras. 13. Sou capaz de exprimir matematicamente as formas de resolução para os problemas com que me deparo no dia-a-dia. 14. Sou capaz de estruturar por escrito um problema matemático expresso verbalmente.
Cooperatividade	15. Gosto de experimentar a aprendizagem cooperativa com o meu grupo de amigos. 16. Na aprendizagem cooperativa, penso que obtenho/obterei melhores resultados porque estou a trabalhar em grupo. 17. Gosto de resolver problemas relacionados com o projeto de grupo juntamente com os meus amigos na aprendizagem cooperativa. 18. Na aprendizagem cooperativa, surgem mais ideias.
Pensamento crítico	19. Sou bom a preparar planos para a resolução de problemas complexos. 20. É divertido tentar resolver os problemas complexos. 21. Estou disposto a aprender coisas desafiantes. 22. Orgulho-me de ser capaz de pensar com grande precisão. 23. Utilizo um método sistemático ao comparar as opções disponíveis e ao tomar uma decisão.
Resolução de problemas	24. Tenho problemas a demonstrar a solução de um problema na minha mente. 25. Tenho problemas na questão de onde e como devo usar as variáveis tais como X e Y na solução de um problema. 26. Não consigo aplicar as formas de resolução que planeio, respetiva e gradualmente. 27. Não consigo produzir tantas opções ao pensar nas possíveis formas de resolução para um problema. 28. Não consigo desenvolver as minhas próprias ideias no ambiente de aprendizagem cooperativa. 29. Cansa-me tentar aprender algo em conjunto com os meus amigos do grupo na aprendizagem cooperativa.