Exploring the Differences in the Cultivation of Computational Thinking in Primary through Meta-analysis based on the Perspective of the Contrast between the East and the West

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Abstract: With the advent of the era of intelligent education, the cultivation and development of computational thinking is the key in talent training. However, most of the existing researches focus on the design of computational thinking teaching methods and models on a small scale, and lack the test of the training effect. Moreover, these effects in existing research are also mixed and fuzzed, and there are even greater differences between the East and the West. Therefore, in order to be able to analyze the effects of computational thinking teaching in depth, meta-analysis can be used to extract the factors that influence the effects of computational thinking in the related research on computational thinking training in the primary school stage in the East and the West. Through the calculation of experimental effect size, the effects of different studies are merged, so as to present the true effect of computational thinking training. A total of 30 qualified literatures were filtered, and 278 effect values were extracted from them. Based on these, the difference in training effects between the East and the West can be calculated to further analyze the development differences of computational thinking in different regions and teaching methods, and then point out the direction for the improvement of computational thinking training methods and models between different regions. The main value of the research is promoting the innovative development of computational thinking training within the globe.

Keywords: Computational thinking, comparative analysis, meta-analysis

1. Introduction

As the era of intelligent education is approaching, talent training needs to focus on the development of higher thinking, especially the cultivation of computational thinking (Pérez, Hijón-Neira, Bacelo, & Pizarro, 2020; Vandercruysse, Vrugte, Jong, Wouters, Oostendorp, Verschaffel, et al., 2016). Computational thinking is also a key aspect of the development of talents in the 21st century. Many countries and regions in the world have incorporated computational thinking into Course syllabus (e.g., Ministry of Education of the People's Republic of China, 2017; Jeong, 2016). In order to enable learners to fully cultivate and develop computational thinking, the cultivation of computational thinking is for all ages and majors, namely we can consider cultivating from the elementary school level (Bers, Ponte, Juelich, Viera, & Schenker, 2002). Existing research shows that cultivating computational thinking for every student from the elementary school level is necessary (Wing, 2014). While developing elementary students' computational thinking, it can also help improve learners' executive functions (EFs, Arfé, Vardanega, Montuori, & Lavanga, 2019). Researchers and practitioners of related fields have begun to devote themselves to the formation of children-oriented computational thinking training programs and strategies (e.g., Papadakis, Kalogiannakis, & Zaranis, 2016). This shows that the development of students' computational thinking is crucial in the primary.

1.1 Literature Review of Computational Thinking Training

In different regions and cultural backgrounds, there may also be differences between the training results of computational thinking. At present, there are certain differences between existing research and practice, both positive and negative. For example, Gülmez and Özdener (2015) has shown that there is a positive correlation between the development of computational thinking in Turkish and the academic achievement. However, in some researches, there is no significant influence between the cultivation of computational thinking and the academic achievement of learners (Doleck, Bazelais, Lemay, Saxena, & Basnet, 2017). At present, many countries and regions were compared to find mutual and suitable theories and practices (Tan and Chua 2015) to realize global education reform (Nóvoa and Yariv-Mashal 2003). Meta-analysis can be used to eliminate the dimensional relationship of different results, and then to realize comparison. At present, for example, there are some meta-analysis studies focus on the relationship between the cultivation of computational thinking and academic achievements from the first grade of elementary school to the fourth grade of university. Moreover, it was found that the results of Oriental computational thinking training were relatively good (Lei, Chiu, Li, Wang, & Geng, 2020). Therefore, we can find out the similarities and differences through the comparison between the East and the West, and provide directions for the future cultivation process of computational thinking.

For the comparison between the East and the West, it can start from the teaching method of computational thinking training, which is the core of the current computational thinking training. For the cultivation of computational thinking, there are still certain obstacles in the teaching method, such as the mismatch between the teaching method and the cultivation of computational thinking, and so on (Barker, McDowell, & Kalahar, 2009; Coull & Duncan, 2011). Existing research shows that pedagogy and teachers' teaching experience are important obstacles to the cultivation of computational thinking (Brackmann, Barone, Casali, Boucinha, & Muñoz-Hernández, 2016; Yadav, Gretter, Hambrusch, & Sands, 2016). Therefore, to compare the differences in computational thinking training effects between the East and the West, we can start from the differences in the teaching methods of computational thinking training between the East and the West.

In addition, we can look at the different levels of computational thinking from the perspective of evaluation. The effects of computational thinking can be further analyzed on the different dimensions and composition of computational thinking. According to the analysis of the composition and level of computational thinking, the current relatively authoritative ideas are as follows. The seven elements of computational thinking proposed by Denning, P. J. (2009), namely Coordination, Communication, Computing, Recollection, Design and Assessment, and Automation. There are also four elements of computational thinking, namely Abstraction, Algorithms, Pattern Recognition, and Decomposition (Shute, Sun, & Asbell-Clarke, 2017; Angeli, Voogt, Fluck, Webb, Cox, Malyn-Smith, & Zagami, 2016). The classic one is 3-D three-dimensional CT framework, which are Concepts, Practices, Perspectives (Brennan, & Resnick, 2012). In this study, the classic 3-D framework is used.

1.2 Objectives

Existing researches related to computational thinking education mostly aimed at testing the effects under the specific cultures or situations in small range. There are relatively many related practices, but they lack the testing of the overall practice effect, and the comparison of practical effects in different regions and conditions. Therefore, meta-analysis was used to test and compare the effects of computational thinking in this study. In addition, in order to promote the formation of localized and adaptive computational thinking training strategies and programs in different countries and regions, the similarities and differences of the effects of primary computational thinking education between Eastern and Western countries are analyzed. In this way, the experience and lessons can be extracted, which can be used for reference in the development of computational thinking education in the future, and then the global innovation and development of computational thinking training can be promoted. The main research question of this study is how can we learn from the differences in computational thinking training in primary between East and the West, and then help with the subsequent localized and adaptive cultivation of computational thinking? Specifically, it can be subdivided into the following three questions:

1. How effective is the cultivation of computational thinking in both the East and the West elementary school?
2. What are the similarities and differences in computational thinking training s in primary between the East and the West?
3. What are the differences in the effect of computational thinking training under different levels and conditions?

2. Methods

2.1 Literature Search

In order to compare the differences of the computational thinking teaching effect between the East and the West, this study chose to use meta-analysis to obtain the training effects on computational thinking Literatures came from two databases, which are Web of Science and CNKI. The search formula in Web of Science Web of Science is that TS = "computational thinking" AND ALL = ("high school" OR "secondary school" OR "higher school" OR "middle school" OR "primary school" OR "K-12" OR "university" OR "school" OR "classroom" OR "online learning" OR "CSCL" OR "Higher education" OR "learn*" OR "student*") AND ALL = ("Random" OR "controlled" OR "experiment*" OR "control group" OR "test" OR "comparison" OR "control" OR "contrast" OR "test group" OR "variable" OR "experimental research" OR "Quasi-experimental research" OR "trail"). A total of 176 documents were obtained from Web of Science. The search formula for obtaining relevant documents in the CNKI database is: SU=(计算思维) AND SU=(试验+对照组+观察组+试验组+实验+测评+考核+测试+成绩+分数+测验+考察+考查). A total of 226 documents were retrieved from CNKI.

2.2 Inclusion criteria

After summarizing the literatures initially obtained, two rounds of screening and reviewing were conducted according to the inclusion criteria. Finally, the number of literatures included in the meta-analysis was 30. Specifically, the inclusion criteria are: (a) the literature must include the cultivation of computational thinking and the measurement of the training effect; (b) literature must be an experimental research article, including two-group pre-test, two-group post-test, a single set of pre- and post-tests, and so on;(c) the literature must include measurement of learning effects (learning performance, learning efficiency, learning motivation, computational thinking levels, etc.), and the effect value can be calculated; (d) delete duplicate documents; (e) the studies are for elementary school. The data required to calculate the effect value mainly includes sample size(N), mean value (M), standard deviation (SD) or t value of the experimental group and the control group. In the first round of screening, a preliminary screening of literatures implemented by reading titles, abstracts, and keywords. And then carefully reading the full text, literatures that fully meet the standards as the data of meta-analysis included in the meta-analysis. After screening according to the above-mentioned criteria in this study, a total of 30 articles were finally included in the meta-analysis (as figure1). Since some documents contain multiple effect values, there are 278 effect values that can be used for meta-analysis.

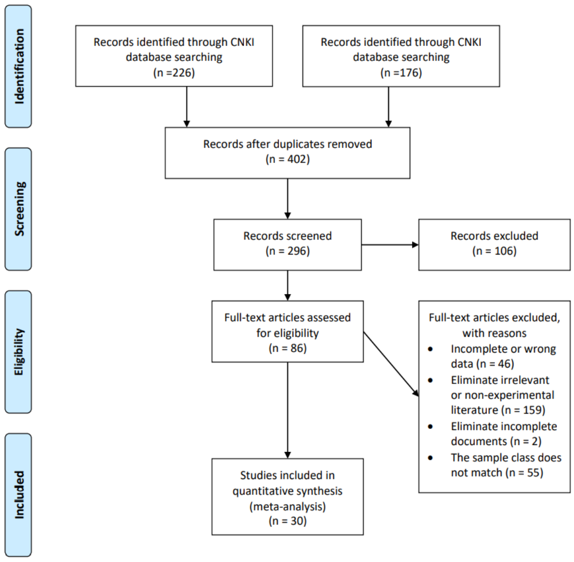

Figure 1. Flow diagram of the document screening process.

2.3 Coding

In order to ensure that accurate and effective information can be extracted from the selected documents, 10 documents were randomly selected as the data for the consistency test of the two coders. Two researchers independently coded 10 articles and performed a consistency test of raters. The calculated scorer consistency is 0.926 (SPSS 21.0, Spearman's rank correlation coefficient), that is, the consistency between the scorers was relatively high. And then, the coders discuss the inconsistencies until they are completely consistent, so that the scorers can perform effective independent coding according to the coding framework.

After discussion between coders, the coding framework was appropriately revised. Finally, the codes included in the coding framework of this study mainly include two categories. In the first part, the basic information of the literature and the research contained in it, as shown in the figure2 (a). Author, Year, Region, Subject, Grade, Grade, Age, Pedagogy, Tools, Experiment period, Sample size (total) are included in this category. The pre-designed options of the teaching method include teaching methods that may have a positive effect on the cultivation of computational thinking as pointed out in the existing research, such as storytelling (Lee et al., 2011), visual coding (Papadakis et al., 2016), unplugged activities (Brackmann et al., 2016). In the second part, values can be used as variable values and attributes to measure the effect of computational thinking training, as shown in the figure2 (b). Experimental group/pretest, Control group/post-test, Type, Classification of learning effects, Measurement, Dimensions of CT are contained in this category. Among them, different types of information can be used as the classification criteria to further compare the effects under different conditions.

NO.	ID	Author，year	Region	Subject	Grade	Grade	Pedagogy	Tools	Experiment period	Sample size (total)
1	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
2	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
3	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
4	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
5	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
6	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
7	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
8	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
9	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
10	00074	Arfe, B., Vardanega, T., & Ronconi, L., 2020	Western	Programing class	Primarry (小学)	First grade	visual block programming	Code.org	5weeks	179
11	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
12	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
13	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
14	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
15	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
16	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
17	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
18	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44
19	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
20	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
21	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
22	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
23	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
24	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
25	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
26	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	80
27	00012	Vardanega, T., Montuori, C., & Lavanga, M	Western	Programing class	Primarry (小学)	First grade	Game-based learning	Code.org	4weeks	44

NO.	ID	Author，year	Experimental group/pretest			Control group/post-test			Type	Classification of learning effects	Measurement	Dimensions of CT
			M	SD	N	M	SD	N				
1	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	-25.32	2.33	88	-4.66	2.87	91	Experimental & control group	coding-Time planning	Test score	Practices
2	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	1.97	0.16	88	1.31	0.18	91	Experimental control group	coding-accuracy	Test score	Practices
3	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	2.92	1.4	88	0.22	-1.25	91	Experimental control group	Elithorn -Time planning	Test score	mean CT scores
4	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	3.93	0.38	88	1.1	2.24	91	Experimental control group	Elithorn -accuracy	Test score	mean CT scores
5	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	0.26	0.36	88	0.08	-0.88	91	Experimental control group	Tower of London -Time planning	Test score	mean CT scores
6	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	3.21	0.27	88	1.27	1.97	91	Experimental control group	Tower of London -accuracy	Test score	mean CT scores
7	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	-8.88	1.26	88	-0.75	-7.14	91	Experimental control group	NEPSY-II-Time planning	Test score	mean CT scores
8	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	-2.25	0.45	88	-0.53	-1.57	91	Experimental control group	NEPSY-II -accuracy	Test score	mean CT scores
9	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	-34.17	5.47	88	-24.46	5.38	91	Experimental control group	STROOP-Time planning	Test score	mean CT scores
10	00074	rfe, B., Vardanega, T., & Ronconi, L., 202	-5.24	0.79	88	-0.71	-1.54	91	Experimental control group	STROOP-accuracy	Test score	mean CT scores
11	00012	Vardanega, T., Montuori, C., & Lavanga, N	25.71	13.92	44	25.5	10.38	44	Pre- & Pro-test	Planning time Elithorn -Planning and response inhibition	Classroom observation	Practices
12	00012	Vardanega, T., Montuori, C., & Lavanga, N	6.75	2.87	44	9.96	3.04	44	Pre- & Pro-test	Accuracy Elithorn -Planning and response inhibition	Classroom observation	Practices
13	00012	Vardanega, T., Montuori, C., & Lavanga, N	7.77	3.33	44	7.22	3.09	44	Pre- & Pro-test	Planning time T oL -Planning and response inhibition	Classroom observation	Practices
14	00012	Vardanega, T., Montuori, C., & Lavanga, N	7.52	2.05	44	9.71	1.86	44	Pre- & Pro-test	Accuracy T oL -Planning and response inhibition	Classroom observation	Practices
15	00012	Vardanega, T., Montuori, C., & Lavanga, N	50.97	7.83	44	45.45	7.92	44	Pre- & Pro-test	hibition time NEPSY -II -Planning and response inhibitio	Classroom observation	Practices
16	00012	Vardanega, T., Montuori, C., & Lavanga, N	2.43	2.43	44	1.56	1.65	44	Pre- & Pro-test	Errors NEPSY -II -Planning and response inhibition	Classroom observation	Practices
17	00012	Vardanega, T., Montuori, C., & Lavanga, N	218	56.13	44	178.1	36.75	44	Pre- & Pro-test	Inhibition time Stroop -Planning and response inhibition	Classroom observation	Practices
18	00012	Vardanega, T., Montuori, C., & Lavanga, N	6.83	6.47	44	2.02	2.38	44	Pre- & Pro-test	Errors Stroop -Planning and response inhibition	Classroom observation	Practices
19	00012	Vardanega, T., Montuori, C., & Lavanga, N	25.5	10.38	44	20.61	11.61	36	Experimental control group	Planning time Elithorn -Planning and response inhibition	Classroom observation	Practices
20	00012	Vardanega, T., Montuori, C., & Lavanga, N	9.96	3.04	44	7.29	3.53	36	Experimental control group	Accuracy Elithorn -Planning and response inhibition	Classroom observation	Practices
21	00012	Vardanega, T., Montuori, C., & Lavanga, N	7.22	3.09	44	8.21	3.33	36	Experimental control group	Planning time T oL -Planning and response inhibition	Classroom observation	Practices
22	00012	Vardanega, T., Montuori, C., & Lavanga, N	9.71	1.86	44	7.85	2.08	36	Experimental control group	Accuracy T oL -Planning and response inhibition	Classroom observation	Practices
23	00012	Vardanega, T., Montuori, C., & Lavanga, N	45.45	7.92	44	47.88	11.46	36	Experimental control group	hibition time NEPSY -II -Planning and response inhibitio	Classroom observation	Practices
24	00012	Vardanega, T., Montuori, C., & Lavanga, N	1.56	1.65	44	2.85	2.35	36	Experimental control group	Errors NEPSY -II -Planning and response inhibition	Classroom observation	Practices
25	00012	Vardanega, T., Montuori, C., & Lavanga, N	178.1	36.75	44	186.1	69.85	36	Experimental control group	Inhibition time Stroop -Planning and response inhibition	Classroom observation	Practices
26	00012	Vardanega, T., Montuori, C., & Lavanga, N	2.02	2.38	44	5.47	5.09	36	Experimental control group	Errors Stroop -Planning and response inhibition	Classroom observation	Practices
27	00012	Vardanega, T., Montuori, C., & Lavanga, N	42.3	22.45	44	11.56	6.29	44	Pre- & Pro-test	Planning time coding-performance at the coding tasks	Classroom observation	mean CT scores
28	00012	Vardanega, T., Montuori, C., & Lavanga, N	4.31	1.46	44	6.12	1.06	44	Pre- & Pro-test	Accuracy coding-performance at the coding tasks	Classroom observation	mean CT scores
29	00012	Vardanega, T., Montuori, C., & Lavanga, N	11.56	6.29	44	38.95	25.26	36	Experimental control group	Planning time coding-performance at the coding tasks	Classroom observation	mean CT scores
30	00012	Vardanega, T., Montuori, C., & Lavanga, N	6.12	1.06	44	3.68	1.92	36	Experimental control group	Accuracy coding-performance at the coding tasks	Classroom observation	mean CT scores
31	00012	Vardanega, T., Montuori, C., & Lavanga, N	20.27	11.58	19	19.17	8.26	19	Pre- & Pro-test	Planning time Elithorn -Planning and response inhibition	Classroom observation	Practices
32	00012	Vardanega, T., Montuori, C., & Lavanga, N	9.79	4.91	19	1268	3.33	19	Pre- & Pro-test	Accuracy Elithorn -Planning and response inhibition	Classroom observation	Practices

(a) documents and their basic information (b) computational thinking training effects and attributes

Figure 2. Coding examples of article coding.

3. Results and Discussion

Based on the extracted data, the comparison between the East and the West can be made according to the training effects under different classification standards with the help of Review Manager 5.4 software. And then, the differences between the East and the West in the cultivation of computational thinking can be found, which can be used for subsequent mutual reference and innovative integration development. Firstly, a brief description of the basic situation of the data is shown. Then, specific analysis of the training effects under different categories includes effect size computation, the heterogeneity test, evaluation of publication bias and moderator analysis. The samples of studies range from 20 to 3629, a total of 6810. It covers relevant research and practice from China, South Korea, the United States, Spain, Italy and other countries.

3.1 Analysis of the Effect of Computational Thinking Training in all Regions

In response to the first research question, how effective is the cultivation of computational thinking in the East and the West as a whole? Specific analysis and discussion will be conducted in terms of effect size calculation, heterogeneity, and publication bias.

3.1.1 Effect Size Computation and the Heterogeneity Test

From the overall comparison, the computational thinking training effect in the relevant education and teaching practice of computational thinking training is tested, and the results are shown in the figure3. The diamond represents the combined effect size, and the center of gravity of the diamond represents the estimated value of the combined effect size, and the width is the confidence interval of the combined effect size. From the diamond circled in the red box on the right side of the figure, it can be seen that the diamond shape as a whole is located in the right of the invalid line, that is, the analysis result is meaningful. Combined with the specific index value, the IV value is 2.79, the 95% confidence interval is 1.42 to 4.17, and the Z value is 3.99 ($p<0.0001$). It can be seen that the overall computational thinking training effect is better than traditional teaching.

From the results shown in the figure3, $I^2=100\%$, and $p<0.00001$, it can be determined that there is heterogeneity between the final studies included in the analysis, which further proves that the random effects model should be used for analysis. So, in order to be more compliant with the randomness in the real education situation, it should be noted that there are certain differences between the samples, the random effects model is chosen to weight the results in different studies, which is conducive to more likely to represent the research group (Marina, Ana, Julio, José, Ángel, 2017).

In addition, from the details of analysis results, the training effect of computational thinking is not all positive or negative. These further shows that computational thinking still has certain problems, which have influenced the stability and adaptability of the training effect. Therefore, in the future cultivation of computational thinking, it is necessary to form a specific and adaptive training program for a corresponding situation.

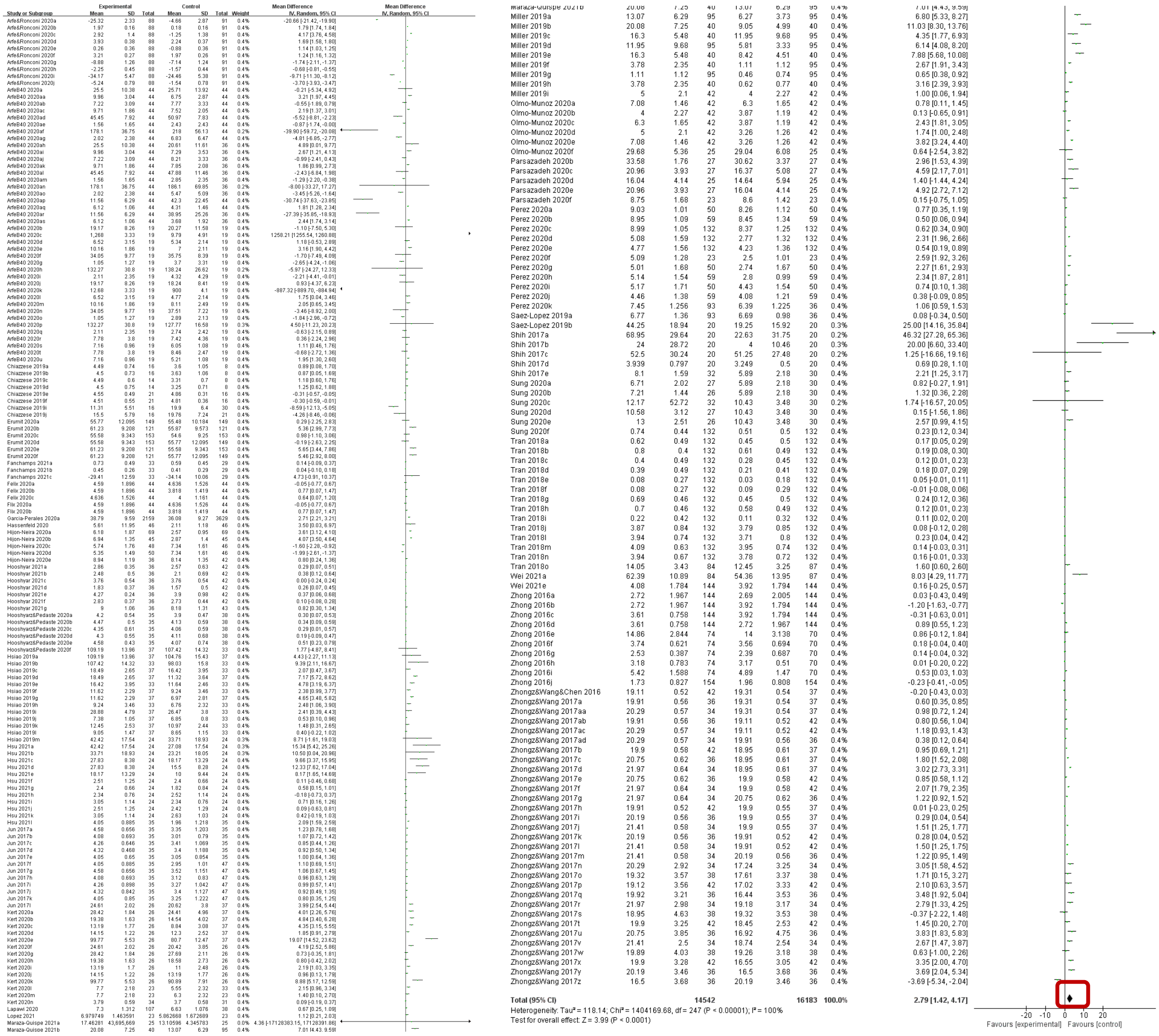

Figure 3. Computational thinking comprehension effect analysis of in all regions.

Therefore, the follow-up will analyze the effects of computational thinking between the East and the West under different conditions, which can provide basis for the development of computational thinking.

3.1.2 Evaluation of Publication Bias

Since the documents included in the meta-analysis in this study are all published documents, there may be situations where more extreme data results are more likely to be published, and certain topics are more likely to be published, that is, there is a publication bias. Therefore, in this study, Review manager 5.0 was used to evaluate the possible publication bias in the research results, and the results are shown in the funnel chart (figure4). It can be seen from the figure that the 30 studies are relatively concentrated on the left side of the average line, and relatively concentrated in the upper half of the figure, which shows that there is little publisher bias in the studies included in the analysis. But, most studies are relatively evenly distributed on both sides of the average line, that is the publication bias is not obvious.

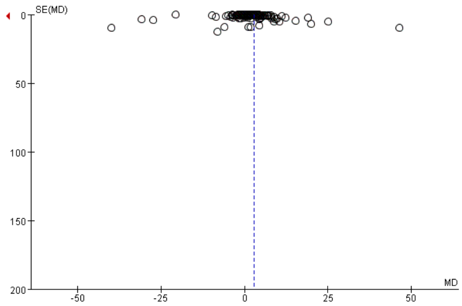

Figure 4. Funnel plot of publication bias analysis of computational thinking training effects in all regions.

3.2 Comparison of the effect of computational thinking training between Eastern and Western

This part mainly responds to the second research question, that is, what re the similarities and differences in computational thinking training effects in primary between East and the West?

3.2.1 Effect Size Computation and The Heterogeneity Test

In the same way, the heterogeneity and publication bias tests of different regional subgroups are carried out by treating the East and West as different subgroups. Firstly, the analysis of the data obtained by the software analysis can show the heterogeneity analysis between the East and the West, as shown in the table1.

Table1 *Results of Analysis of The Heterogeneity of Computational Thinking Training Effects in the East, the West, and between the East and the West*

Groups			**Tau²**	**Chi²**	**I²**	**Mean difference and 95% confidence interval**			**Weight**	**Z**	**P**
Group	**Number studies**	**df**				**IV（mean difference）**	**Lower limit**	**Upper limit**			
Western	21	155	144.68	1402647.02	100%	2.82	0.91	4.73	63.1%	2.89	0.004
Eastern	10	90	0.99	2107.15	96%	-0.37	-0.61	-0.13	36.8%	3.01	0.003
Subgroup difference		1	\	10.54	90.5%	\	\	\	\	\	0.001

From the results in the table1, the I^2 of the East and the West are 100% and 96%, the corresponding p-values are both less than 0.01. Therefore, it can be shown that there is a large heterogeneity within the East and West groupings, which requires the use of random effects models for analysis. Moreover, the I^2 between the eastern and western studies was 90.5%, which indicates that the heterogeneity between the two groups is relatively high, and the p-value between the two groups is 0.001<0.01, which indicates that there are significant differences between the East and the West.

Moreover, by comparing the IV values of the East (-0.37, [-0.61, -0.13]) and the West (2.82, [0.91, 4.73]) and the corresponding confidence intervals. This means that Eastern computational thinking training has not gotten significant positive effects. It can also be found from Z values in the cultivation of computational thinking, that is, the West (Z=2.89) is relatively better than the East (Z=3.01). But, since the cultivation of computational thinking in the East has crossed the invalid line, it is still that the overall effect of computational thinking in the West is better than that of the East. The reason may lie in the following two aspects. On the one hand, it may be because the research with inverted results is easier to be accepted and published in the East. On the other hand, it may be because the computational thinking training effect in the East is slightly inferior to that in the West.

3.2.2 Evaluation of Publication Bias

Similarly, with the help of software analysis, the funnel chart can be used to analyze whether there are publication biases in Eastern and Western studies, as shown in the figure5. There is a large similarity in publication bias between the East and the West, and they are also concentrated on the left side of the average line, which means that some negative results may not be published. In other words, whether it is in the East or the West, the effect of computational thinking training requires more publication of real results. However, relatively speaking, Eastern studies are more evenly distributed. This is mutually corroborated with the previous reasons that may lead to the difference in results for Effect size computation and the heterogeneity test between the East and the West, that is, the effect of the Oriental computational thinking training is not ideal. So, there is urgently need for East to learn from the relevant research and practice about computational thinking's training in the West.

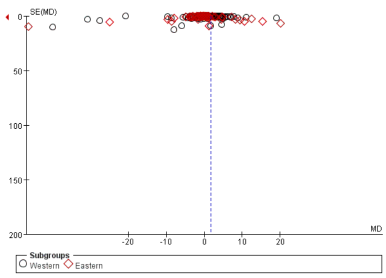

Figure 5. Results of analysis of the publication bias of computational thinking training effects in the East, the West, and between the East and the West.

3.3 Comparison of the Effect of Computational Thinking Training Under Different Condition between the East and the West.

In response to the third sub-question, what is the specific manifestation of the difference between the eastern and western computational thinking training effects? Comparison and analysis are carried out from the perspective of the difference between the teaching method of computational thinking training and the method of measuring teaching effect.

3.3.1 Differences in Cultivation Effects of Eastern and Western Computational Thinking Under Different Teaching Methods

Combining the combing and summarizing results of literature review, pedagogy is an important influencing factor of education and teaching practice, and is the core element to achieve teaching and training goals. Hence, it is mainly aimed at the comparison of cultivation effect difference on computational thinking between the East and the West under different teaching methods.

From the table2, the results can be obtained by processing and analyzing the effects of developing computational thinking in the East and the West under different teaching methods.

It can be found from the table that collaborative scripting and game-based learning have large internal differences on the effect of computational thinking's cultivation in the West. The index IV values are 5.33 and 4.02 respectively. The scaffolding has relatively little internal difference on computational thinking training. But, it should be noted that this method with an index of 0.08, and the confidence interval contains 0, which can be judged that scaffolding has no significant positive effect in the cultivation of computational thinking. In the eastern computational thinking training results, it can be found that game-based learning still has large internal differences on the effect of computational thinking's cultivation, while the digital story teaching method has smaller internal differences in computational thinking training. But, its confidence interval has not been crossed 0.

Table 2. *Comparing the Effects of Computational Thinking between the East and the West under Different Teaching Methods*

Groups			**Tau^2**	**Chi^2**	**I^2**	**Mean difference and 95% confidence interval**			**Weight**	**Z**	**P**
	Group	**df**				**IV (mean difference)**	**Lower limit**	**Upper limit**			
Western	**Computational perspective-taking practices**	5	0.26	7.91	37%	1.47	0.77	2.17	3.9%	4.10	<0.0001
	Collaboration script	9	7.48	245.91	96%	5.33	3.53	7.13	6.8%	5.80	<0.00001
	Game-based learning	76	252.29	1391565.96	100%	4.02	0.43	7.60	51.5%	2.20	0.03

	Learn by doing	26	2.18	423.29	94%	1.74	1.11	2.36	18.5%	5.47	<0.00001
	MECOPROG methodology	10	0.72	148.89	93%	1.20	0.67	1.73	7.6%	4.47	<0.00001
	Scaffolding	2	0.01	3.14	36%	0.08	-0.11	0.28	2.0%	0.85	0.39
	Visual block programming	14	0.37	596.81	98%	1.04	0.68	1.40	9.6%	5.69	<0.00001
	Subgroup difference	6	\	86.56	93.1%	\	\	\	\	\	<0.00001
Eastern	**Learn by doing**	14	3.71	144.59	90%	2.73	1.58	2.59	12.9%	4.65	<0.00001
	DBL	11	0.04	20.62	47%	1.06	0.90	1.22	19.1%	13.01	<0.00001
	Digital storytelling	13	0.25	114.45	89%	0.33	0.02	0.64	19.8%	2.10	0.04
	Game based learning	4	295.72	49.24	92%	17.81	1.57	34.05	1.7%	2.15	0.03
	Pair programming (PP)	32	1.09	1558.05	98%	1.56	1.18	1.95	46.5%	7.96	<0.00001
	Subgroup difference	4	\	39.95	90.0%	\	\	\	\	\	<0.00001

Among them, we can focus on game-based teaching methods. Judging from the existing research, the effect of educational games on the cultivation of computational thinking can be determined (e.g, Hwang, Chiu, Chen, 2015; Sung & Hwang, 2013; Kuruvada, Asamoah, Dalal, & Kak, 2010; Zhao & Shute, 2019). Educational games are currently widely used in the education field to meet the needs of users (Gloria, Bellotti, & Berta, 2014), and use game elements such as competition and incentives to motivate and inspire learners (Turan, Avinc, Kara, & Goktas, 2016), thereby promoting the improvement of academic performance (Majuri, Koivisto, & Hamari, 2018). However, in this study, the improvement level of the computational thinking training effect of the East and the West is similar (the Z value of the computational thinking training effect of the East is 2.15, and that of the West is 2.20), and from the perspective of the P value (the p value is both 0.03), the training effect of computational thinking is not significantly improved. But the reason why it is not a significant improvement might lie in the mismatch between the design needs of the teaching method and the teaching content and teaching arrangement (Angeli & Giannakos, 2020; Farnqvist, Heintz, Lambrix, Mannila, & Wang, 2016). Therefore, in the future, the use of game-based teaching methods and other teaching methods in the process of computational thinking training should be given matching problem situations and teaching designs.

From the perspective of the effect size of standardized computational thinking training represented by the Z value, collaborative scripting (Z=5.80), learning by doing (Z=5.47) and visual programming (Z=5.69) have better training effects in the West, while DBL (Design based learning, Z=13.01) and Pair programming (PP, Z=7.96) have better training effects in the East. The common point of these studies is that they can provide a certain problem context and promote learners to formulate and implement solutions in accordance with established goals. This is consistent with the emphasis in existing research that the need to cultivate computational thinking based on certain problem situations (Hooshyar, Malva, Yang, Pedaste, Wang, & Lim, 2021).

Therefore, we can learn from each other based on the difference in the training effect between the eastern and western computational thinking training methods in the follow-up education and teaching practice. It should be noted when using the above-mentioned teaching methods that it is necessary to have a good teaching design to support, and give full play to its role in the cultivation of computational thinking in primary.

3.3.2 Differences in the cultivation of computational thinking between the East and the West at different levels

It can be seen from the table3 that the development of Western computational thinking has a relatively good effect at the conceptual level, with a Z value of 11.90; while the development of computational thinking in the East performs relatively well at the perspectives level and outperforms the West, but It is relatively weak in the other three dimensions. Among them, both the East and the West perform relatively poorly at the operational level of computational thinking, and their Z values are the smallest among the four comparative dimensions. The reason for paying attention to the performance of computational thinking in different dimensions is to infer how to make targeted adjustments to computational thinking through the insufficiency of evaluation and results. Existing research also emphasizes the importance of computational thinking evaluation (Grover & Pea, 2013). Therefore, in the training of computational thinking in the future, it is necessary to pay attention to the balanced development of computational thinking at different levels, especially to improve the ability of primary school learners at the operational level of computational thinking, which can also meet the needs of the 21st century to cultivate fully developed talents demand.

Table 3. *Comparing the effects of computational thinking between the East and the West under different teaching methods*

Groups			Tau²	Chi²	I²	Mean difference and 95% confidence interval			Weight	Z	P
	Group	df				IV（mean difference）	Lower limit	Upper limit			
Western	Concepts	39	0.23	854.76	95%	1.11	0.93	1.29	35.3%	11.90	<0.00001
	Perspectives	12	0.03	23.16	48%	0.48	0.33	0.64	11.9%	6.07	<0.00001
	Practices	12	0.13	140.94	91%	0.62	0.35	0.89	10.4%	4.51	<0.00001
	Mean CT scores	55	1.86	4178.26	99%	0.77	0.85	1.20	42.5%	3.74	0.0002
	Subgroup difference	3	\	27.17	89.0%	\	\	\	\	\	<0.00001
Eastern	Concepts	13	11.82	85.20	85%	7.36	4.94	9.77	4.3%	5.97	<0.00001
	Perspectives	49	0.54	836.57	94%	1.17	0.94	1.40	64.3%	9.91	<0.00001
	Practices	9	0.48	41.02	78%	0.94	0.39	1.50	10.5%	3.31	0.0009
	Mean CT scores	16	0.39	179.89	91%	0.62	0.27	0.98	20.9%	3.45	0.0006
	Subgroup difference	3	\	32.94	90.9%	\	\	\	\	\	<0.00001

4. Conclusion and Limitations

In general, this research uses meta-analysis to compare and analyze the effects of the East and the West on the cultivation of primary school students' computational thinking. First of all, on the whole, the effect of the East and the West on the cultivation of primary school students' computational thinking is positive, and there is no obvious publication bias, and the results of relevant research can be published truthfully. Secondly, the effect of the cultivation of computational thinking in the East and the West is shown by meta-analysis. The cultivation effect of computational thinking in the West is better than that in the East on the overall level. Therefore, in the future, the cultivation of computational thinking for primary school students in the East need to learn from the West. The specific development direction that needs reference and attention can be obtained through the third conclusion. Thirdly, there are still big differences between the East and the West in terms of the teaching methods and the effects of different levels of computational thinking training. Among them, the related teaching methods with collaborative nature, learning by doing, and visualization have relatively good results in the cultivation of computational thinking. In the future, the cultivation of computational thinking can be focused on, supplemented by supporting teaching design. In terms of effects at different levels, primary school students in the East and the West are generally relatively weak at the operational level, and they need to be focused on in the future research on education and teaching practice.

However, this study also has the following shortcomings. Firstly, it only analyzes the effect of computational thinking training in elementary school. The target groups of the study are relatively focused. Furthermore, there may be other differences in the effect of computational thinking training in different groups in the East and the West. This is also the future research will continue. Secondly, the comparison and analysis between the East and the West in the research only paid attention to the core computational thinking training pedagogy and the different aspects of the training effect. In future research, more dimensions will be used for comparison and analysis.

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