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Impactul programelor de dezvoltare profesională a cadrelor didactice asupra
abilităților de citire ale elevilor din școala primară: studiu meta-analitic

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THE IMPACT OF PROFESSIONAL DEVELOPMENT PROGRAMS OF TEACHERS ON THE READING SKILLS OF PRIMARY SCHOOL STUDENTS: A META-ANALYTIC STUDY

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Abstract

The current meta-analysis evaluated the impact of teacher professional development programs (TPDP) on student reading skills for non-struggling readers and struggling

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readers from the preparatory grade to the fourth grade in general education. We analyzed 15 randomized controlled trials and quasi-experimental studies that focused on professional development of primary school teachers and measured code-focused, meaning-focused, or general reading skills at primary school students level. We also explored if the elements of study design, characteristics of the participants, features of the TPDP, outcomes measured, or context of the study are potential moderators of the effects. Results indicate that TPDP have a statistically non-significant general effect size ($k = 15$, $d = 0.068$, $SE = 0.049$, $Z = 1.394$, $p = .162$) but a significantly small effect size ($d = 0.201$, $SE = 0.078$, $Z = 2.574$, $p = .010$) in the case of fourth grade students. We did not identify publication bias. Classical programs rather than hybrid programs (that also include coaching, mentoring, or feedback sessions) as well as a smaller number of program sessions seem to be more effective. Future research is necessary to identify effective features of TPDP and the impact on the teachers' teaching skills.

Keywords: meta-analysis, primary school, reading skills, systematic review, teacher professional development programs (TPDP).

Rezumat

Meta-analiza de față a evaluat impactul programelor de dezvoltare profesională pentru cadrele didactice (PDPCD) asupra abilităților de citire ale elevilor cu sau fără dificultăți de citire, de la clasa pregătitoare până la clasa a IV-a din școlile de masă. Am analizat 15 studii experimentale și cvasi-experimentale care s-au centrat pe dezvoltarea profesională a cadrelor didactice de școală primară și au măsurat abilitățile de citire centrate pe cod, abilitățile de citire centrate pe semnificație sau abilitățile generale de citire ale elevilor de la ciclul primar. Am explorat, totodată, dacă elementele legate de designul studiului, caracteristicile participanților, caracteristicile PDPCD, rezultatele măsurate sau contextul în care s-a desfășurat studiul sunt potențiali moderatori ai efectelor. Rezultatele indică faptul că, în general, PDPCD au o mărime a efectului nesemnificativă ($k = 15$, $d = 0.068$, $SE = 0.049$, $Z = 1.394$, $p = .162$), dar și faptul că pentru elevii de clasa a IV-a au o mărime a efectului semnificativă de intensitate scăzută ($d = 0.201$, $SE = 0.078$, $Z = 2.574$, $p = .010$). Nu am identificat distorsiuni ale rezultatelor. Programele clasice, mai degrabă decât cele hibrid (care includ și sesiuni alternative de feedback, coaching sau mentorat) și numărul mai mic de sesiuni par să fie mai eficiente din perspectiva datelor analizate. Sunt necesare cercetări viitoare pentru a identifica caracteristicile eficiente ale PDPCD și impactul asupra competențelor de predare ale cadrelor didactice.

Cuvinte-cheie: abilități de citire, evaluare sistematică, meta-analiză, programe de dezvoltare profesională pentru cadrele didactice (PDPCD), școală primară.

1. Introduction

1.1. The Rationale for the Study

Teacher professional development programs (TPDP) are fundamental to improving teaching knowledge and skills and, at the same time, to change teacher attitudes and perceptions that, in turn, should affect teaching quality in the classroom. High-quality instruction is necessary to develop students' reading skills for both non-struggling readers and struggling readers in primary school. The previous meta-analyses showed that TPDP improved student reading achievement in kindergarten through eighth grade (Basma & Savage, 2018; Didion et al., 2020). However, there is a lack of information in the literature regarding efficient features of TPDP that produce a positive effect on student reading outcomes (Basma & Savage, 2018; Didion et al., 2020). Moreover, the previous meta-analyses did not identify the study characteristics and the participants' characteristics that moderated the effect of TPDP on the reading outcomes (Didion et al., 2020). Also, we could not find previous meta-analyses in the reading domain that also evaluate the impact of the TPDP on the teacher-level outcomes. Thus, questions remain about how teaching skills and teachers' perceptions changed due to the interventions, and how this affects the relationship between TPDP and students' reading skills. Therefore, in the present study we focus on the impact of TPDP on the student reading skills from the preparatory grade to the fourth grade in general education. Furthermore, we explore which are the efficient features of the TPDP that improve the student reading skills and which are the characteristics of the study, characteristics of the intervention context and characteristics of the participants that affect the effect of the TPDP. Complementary, we explored the impact of TPDP on teacher-level outcomes.

1.2. Input from previous meta-analyses

Basma and Savage (2018) explained the need to divide research on professional development, that is, the need to separate the studies that explore the effect of TPDP on student outcomes in different domains. The authors explained that the merger of outcomes from distinct disciplines could be

problematic because it has not been tested whether the effectiveness of TPDP is comparable in different domains such as reading, mathematics or science and, also, whether the teaching methods can be compared in these domains. On the other hand, the authors highlighted that the merger of data could produce an unclear picture on the literature of TPDP in the reading domain. If such meta-analysis mainly included studies that measured mathematics and science outcomes and the results showed a significant effect of TPDP on student outcomes, it could generate a false positive conclusion about the effectiveness of TPDP in the reading domain. Therefore, Basma and Savage (2018) conducted the first meta-analytic study that investigated the effect of TPDP on reading achievement at kindergarten through fifth grade students-level, in the general education. Furthermore, their study explored what variations in TPDP moderated the overall effect. The authors identified 13 different programs in the 17 included studies. The results showed a small, positive, significant effect of TPDP on reading achievement for students in kindergarten through fifth grade. In terms of the moderators, the analyses indicated that shorter TPDP with less than 30 hours in length produced a larger effect on student reading achievement than longer TPDP of more than 30 hours in length. The authors evaluated the quality of the studies included in the meta-analysis and examined the relationship between the duration in hours and the study quality. The results showed that high-quality studies that delivered shorter programs had the highest significant effect on student reading achievement.

The study of Didion et al. (2020) analyzed the TPDP impact on elementary school and middle school students' reading achievement. The authors included 28 studies and explored whether characteristics of TPDP moderated the general effect. The authors identified five different formats of TPDP: whole group, summer coursework, professional learning communities, coaching, online training. In addition, the study explored whether participants' characteristics, measured outcomes, experimental design or replicable quality moderated the impact of TPDP on students' reading achievement. This meta-analysis evaluated three categories of reading skills: code-focused skills, meaning-focused skills, and general reading skills. In the first grades of elementary school, students learn to read accurately and fluently. Specifically, they develop code-focused skills like phonological awareness, word identification, decoding and fluency. In the last grades of elementary school, students read in order to extract and

learn new knowledge from the text and understand the meaning of the text. Thus, they develop meaning-focused skills like vocabulary and comprehension. Results indicated that the study design, the features of the program and the participants' characteristics did not moderate the effect of TPDP on the students' reading achievement. However, the results showed a general positive, significant effect of TPDP on reading achievement for students in kindergarten through eighth grade.

The previous meta-analyses that measured the impact of TPDP on reading outcomes, focused on students with diverse characteristics and needs at different levels of education. Didion et al. (2020) mixed data from 25 studies that focused on elementary school, only one study that focused on middle school, and two studies that focused on both. The analysis showed a small positive significant effect of TPDP on students' reading outcomes. This might generate a wrong conclusion about effectiveness of TPDP on reading skills of students included in middle school. In addition, Didion et al. (2020) blended data from 19 studies that focused on general education, three studies that included students with reading difficulties, only one study focused on special education, and five studies that focused on both special and general education. This merger of data might generate multiple questions about the comparability of students' needs, teaching methods for different type of students' needs, and, consequently, about comparability of TPDP focused on general education or special education. We assumed that aggregating data from studies that focused on pre-university education in general, might generate an imprecise view of the effectiveness of TPDP at different levels of education. Also, TPDP delivered in general education should be different compared to TPDP delivered in special education. Students with different needs require differentiated instruction which, in turn, requires different knowledge and skills for teachers and different TPDP.

1.3. The Purpose of the Study

The purpose of the present meta-analysis is to evaluate the impact of the TPDP on the student reading skills for non-struggling readers and struggling readers from preparatory grade to the fourth grade in general education. An additional aim is to investigate the impact of TPDP on teachers' teaching

skills. We also aim to explore whether the design of the studies, the characteristics of the participants, the context of the interventions and the features of the programs could moderate the general effect of TPDP.

In accordance to the intended purpose, we formulated the following research questions:

- Q1. What is the effect size of the TPDP on the student reading skills from preparatory grade to fourth grade in general education?
- Q2. What is the effect size of the TPDP on the reading skills for struggling readers compared to non-struggling readers from preparatory grade to fourth grade in general education?
- Q3. What are the effects of the TPDP on the student reading skills for distinct grade levels?
- Q4. What are the effects of the TPDP on distinct reading skills (phonological awareness, decoding, word identification, fluency, vocabulary, comprehension) for preparatory grade students to fourth-grade students?
- Q5. What are the effects of TPDP on the teaching skills of teachers from intervention groups compared to teachers from control groups?
- Q6. What features of the TPDP moderate the effect on student reading skills?
- Q7. What characteristics of participants moderate the effect on student reading skills?
- Q8. What characteristics of study design moderate the effect on student reading skills?
- Q9. What characteristics of the intervention context moderate the effect on student reading skills?

2. Method

2.1. Inclusion Criteria

Studies needed to meet the following criteria to be included in the present meta-analysis:

- independent variable(s) should include one or more of the following professional development formats: a) whole group, b) summer coursework, c) professional learning communities (including teacher study

- group), d) coaching, e) online training;
- dependent variable(s) should include one or more of the following student reading skills: a) phonological awareness, b) decoding, c) word identification, d) fluency, e) vocabulary, f) comprehension;
 - TPDP addressed in-service teachers who taught in preparatory - fourth grade in general education;
 - students were included in preparatory - fourth grade in general education;
 - students were struggling readers (who do not need special educational services) or non-struggling readers included in general education;
 - studies used a randomized controlled trials (experimental) or quasi-experimental design;
 - studies used a business-as-usual condition or waiting list condition to compare the effectiveness of the TPDP;
 - studies included necessary data to calculate the effect size;
 - studies were published in English Language.

2.2. Search Strategies

We identified 15 research studies through three search strategies: (1) we selected appropriate studies included in the previous meta-analyses, (2) we searched studies in databases using keywords and (3) we hand searched through peer-reviewed journals that focused especially on professional development and reading domain. First, we analyzed the two previous meta-analyses (i.e., Basma & Savage, 2018; Didion et al., 2020) that evaluated the effect of TPDP on students' reading achievement. We obtained 45 relevant references and removed five duplicated articles. Because we could not find the full text of 8 studies, we analyzed only 32 studies included in previous meta-analyses. After applying the inclusion criteria, we identified 11 eligible studies.

Second, we searched studies published in peer-reviewed journals and unpublished manuscripts through electronic databases using the search engine EBSCOhost. The search was carried out for studies published between 01.01.2014 - 19.09.2019. We used keywords combined using Boolean search functions "AND", "OR" as follows: ("*program**" OR "*programme**") AND ("*reading*" OR "*reading outcome*") AND ("*professional development*" OR "*teacher professional development*" OR "*teacher training*") AND

("primary school" OR "elementary school"). We identified 15 studies, but we selected only two as eligible after applying the inclusion criteria.

Third, we searched for studies published between 2015 - May 2020, in the following journals: *Assessing Writing, Reading and Writing, Scientific studies of reading, Reading research quarterly, Teaching and Teacher Education, Educational Technology Research and Development, Journal of Teacher Education*. In addition, we searched for studies published between 2019 - May 2020 in the following journals: *American Educational Research Journal, International Journal of Speech-Language Pathology, The Journal of Literacy Research (JLR), Language & Education: An International Journal, Literacy Research and Instruction, Reading Teacher, The Elementary School Journal, The Journal of Educational Research*. We identified 38 studies and excluded 36 studies that did not meet inclusion criteria. Therefore, we included two other studies after the third search strategy.

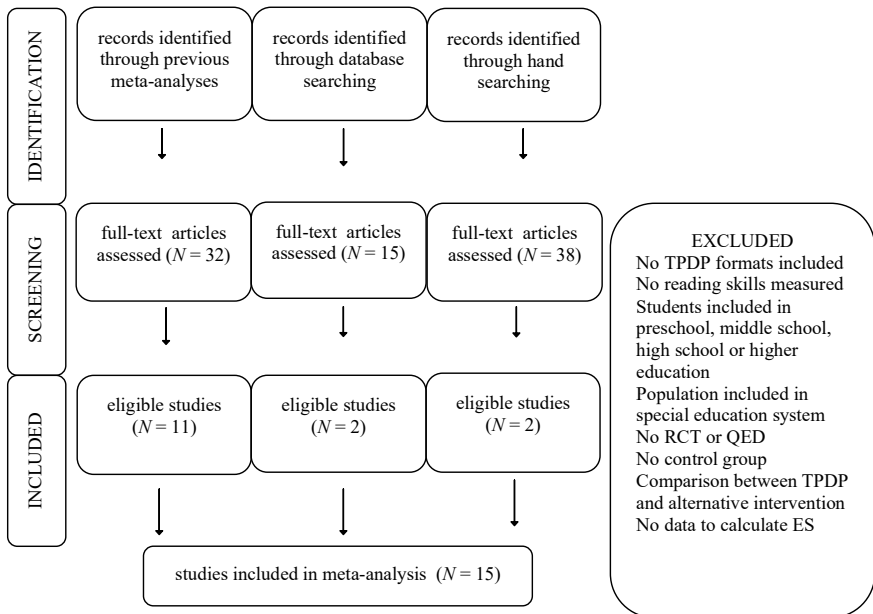


Figure no. 1. Literature Review and Selection of Articles

2.3. Coding Procedures

We used a coding scheme which includes the following sections: 1) manuscript data, 2) features of the TPDP, 3) measured outcomes, 4) characteristics of the participants, 5) characteristics of the study design, 6) characteristics of the intervention context, 7) statistical data. To obtain information about independent variable, we extracted the following features of TPDP: name, aim, format, format design (singular format or multiple format), instructional activities type, content focus, provider of the program, sessions number, hours number, instruction focus, use of technology for TPDP delivery, teachers' participation type, theoretical foundation. We extracted the following measured reading skills at the student-level: code-focused skills, meaning-focused skills, and general reading skills. Also, we coded the following teachers' characteristics: gender, age, teaching experience, employment type, specialization, grade, previous participation in TPDP (in the reading domain). Complementary, we extracted the following students' information: gender, age, grade, status, and native language. To evaluate the study design, we focused on research type, design type, analysis, and control group. The characteristics of the intervention context are another important aspect for our meta-analysis, thus we coded: country, area (urban or rural) and school type. To calculate the effect size, we extracted: number of participants, means and standard deviations of each outcome, for both experimental and control groups. Also, we extracted information related to dropout from research.

2.4. Statistical Methods

We used the values of means, standard deviations and the number of participants included both in experimental and control group to calculate the effect size. In the case of the following two studies Gersten et al. (2010) and Jayanthi et al. (2018) we extracted the effect size value (Cohen's *d*) and the number of participants. Thus, we introduced all the data into the Comprehensive Meta-Analysis software, CMA version 3.0 (Borenstein et al., 2013). We calculated the standardized mean difference between the group of students whose teachers received any kind of TPDP format and the group of students whose teachers were included in the control group,

using the post-test data. The effect size indicator used to measure the student reading outcomes was Cohen's *d*. All eligible and independent effect sizes from each study were included for analyses. We assumed that there are variations of the effect sizes from one study to another caused by the characteristics of the studies, rather than caused by the sampling errors. The studies reported different formats of TPDP, and distinct teachers' characteristics and students' characteristics. Thus, we assumed that there is no equal effect size for all the studies. Therefore, we used the random-effects model for meta-analysis. We assessed the heterogeneity between studies using the Q-test and the I-square. Also, we assumed that characteristics of the participants, design of the TPDP, design of the studies or context in which the interventions were conducted, could be the potential moderators of these effects. Thus, we ran subgroup analyses and meta-regression to identify whether the effect varied across the characteristics of the studies. We developed two distinct databases as follows: a) studies that compared equivalent groups (i.e., non-struggling readers in experimental group vs non-struggling readers in control group or struggling readers in experimental group vs struggling readers in control group), and b) studies that compared non-equivalent groups (i.e., struggling readers vs non-struggling readers). We conducted separate analyses for each situation.

3. Results

3.1. Meta-analysis

Table no. 1 reports the study design, the participants' characteristics, instruments used and effect sizes. In addition, Table no. 2 reports features of TPDP: name, format, content focus, provider of the program, number of sessions, number of hours, instruction focus and use of technology to deliver the program.

Table no. 1. Characteristics of the Study

Study ID	Study design	Intervention group N	Comparison group N	Student Outcome Measure(s)	Cohen's <i>d</i>
Alexander et al. (1987)	RCT	73 - 4th grade training and teacher not observed	240 - 4th grade control	Woodcock Reading Mastery Tests, Forms A and B The word comprehension subtest	0.277
		141 - 4th grade training and teacher observed	240 - 4th grade control		0.065
Amendum & Liebfreund (2019)	RCT	27 - 1st grade Struggling readers	19 - 1st grade Non-struggling readers	Woodcock-Johnson III Diagnostic Reading Battery (4 subtests) Word Attack Letter-Word Identification	-1.298
		24 - 2nd grade Struggling readers	15 - 2nd grade Non-struggling readers	Spelling of Sounds Passage Comprehension	-1.706
Amendum (2014)	RCT	29 - 1st grade Struggling readers	16 - 1st grade Non-struggling readers	Woodcock-Johnson Diagnostic Reading Battery-III (4 subtests) Word Attack Letter-Word Identification Spelling of Sounds Passage Comprehension	-1.344
Collins et al. (2017)	RCT	249 two years 4th grade	107 4th grade	The fourth-grade NYS English language arts	0.797
		146 one year 4th grade	107 4th grade		0.296
Gersten et al. (2010)	RCT	273 - 1st grade	302 - 1st grade	WDRB Reading Vocabulary Passage Comprehension	-0.170
Jayanthi et al. (2018)	RCT	863 - 1st grade	817 - 1st grade	Woodcock Johnson III (WJ) Reading Vocabulary Group Reading Assessment and Diagnostic Evaluation (GRADE) Word Meaning subtest	-0.065

Study ID	Study design	Intervention group N	Comparison group N	Student Outcome Measure(s)	Cohen's <i>d</i>
Knezek & Christensen (2007)	RCT	238 - 1st grade	119 - 1st grade	The Texas Primary Reading Inventory (TPRI)	0.212
		242 - 2nd grade	70 - 2nd grade		-0.010
Lange (2019)	RCT	55 - 3rd grade	34 - 3rd grade	Measure My Reading (MMR) The Gray Oral Reading Test- 5th Edition (GORT-5) The Developmental Reading Assessment—2nd Edition (DRA-2) New Jersey Assessment of Skills and Knowledge—English Language Arts (NJASK-ELA) The Early Language and Literacy Classroom Observation (ELLCO K-3)	0.031
Podhajski et al. (2009)	QED	33 - 1st grade	14 - 1st grade	Dynamic Indicators of Basic Early Literacy Skills (DIBELS): Letter Naming Fluency Phonemic Segmentation Nonsense Word Fluency	-0.046
		21 - 2nd grade	22 - 2nd grade	Texas Primary Reading Inventory The Oral Reading Fluency Reading/Listening Comprehension Test of Word Reading Efficiency (TOWRE): The Sight Word Efficiency The Phonemic Decoding Efficiency	-0.324
Seifert et al. (2016)	QED	159 - 2nd grade	218 - 2nd grade	The SLRT- II (2 subscales) Pseudowords Words subscales Reading Comprehension Test for First to Sixth Graders (2 subscales used) Word comprehension subscale Sentence comprehension subscale	-0.008

Study ID	Study design	Intervention group N	Comparison group N	Student Outcome Measure(s)	Cohen's <i>d</i>
Snow et al. (2014)	RCT	460 1st grade 2nd grade	316 1st grade 2nd grade	Reading Progress Test	0.248
van Kuijk et al. (2016)	QED	55 - 2nd grade 45 - 3rd grade	53 - 2nd grade 47 - 3rd grade	The Cito standardized reading comprehension assessments	0.107
Vernon-Feagans et al. (2010)	RCT	19 - 1st grade	29 - 1st grade	The Woodcock-Johnson Tests of Achievement, III (2 subtests)	-0.839
		Struggling EXP	Struggling CTR	Word Attack	-1.429
		Struggling EXP	Not struggling EXP	The Letter-Word Identification	-1.081
		Struggling EXP	Not struggling CTR	The Peabody Picture Vocabulary Test-Third Edition (PPVT-III)	-1.081
Vernon-Feagans et al. (2012)	RCT	34 - 1st grade	41 - 1st grade		
		Struggling EXP	Struggling CTR	Woodcock Johnson III, Diagnostic Reading Battery (2 subtests)	-0.183
		Struggling EXP	Non-struggling EXP	The Letter-Word Identification (LWI) subtest	-0.776
		Struggling EXP	Non-struggling CTR	The Word Attack (WA) subtest	-0.807
Vernon-Feagans et al. (2013)	RCT	102 - 1st grade	109 - 1st grade		
		Struggling readers	Struggling readers	Woodcock-Johnson III Diagnostic Reading Battery (4 subtests)	0.281
		Struggling intervention	Non-struggling intervention	Word Attack	-0.716
		Struggling intervention	Non-struggling control	Letter Word Identification Passage Comprehension Spelling of Sounds The Peabody Picture Vocabulary Test—III	-0.706

Table no. 2. Characteristics of the TPDP

Study ID	TPDP name/ format	Primary content focus	TPDP instruction type	Provider of TPDP	No. sessions/ No. hours	TPDP instruction focus
Alexander et al. (1987)	PDAlexander whole group	reading instruction to improve meaning-focused skills	classical	research team face-to-face	2 s / 8 h	teachers' knowledge and skills
Amendum & Liebfreund (2019)	ENRICH summer coursework, coaching	reading instruction for struggling readers	classical and alternative	mixed face-to-face	NA / NA	teachers' knowledge and skills
Amendum (2014)	ENRICH summer coursework, coaching	reading instruction for struggling readers	classical and alternative	mixed face-to-face	NA / NA	teachers' knowledge and skills
Collins et al. (2017)	WIRC summer coursework	reading instruction to improve meaning-focused skills	classical	research team face-to-face	5 s / NA	teachers' skills
Gersten et al. (2010)	TSG professional learning communities (teacher study group)	reading instruction to improve meaning-focused skills	alternative	research team face-to-face	16 s / 20 h	teachers' knowledge and skills
Jayanthi et al. (2018)	TSG professional learning communities (teacher study group)	reading instruction to improve meaning-focused skills	alternative	facilitators face-to-face	10 s / 12.5 h	teachers' knowledge and skills
Knezek & Christensen (2007)	PDKnezek summer coursework	using technology in classroom	classical	facilitators face-to-face	5 s / NA	teachers' skills
Lange (2019)	PDLange whole group	using technology in classroom reading instruction to improve meaning-focused skills	classical and alternative	mixed face-to-face	NA / 5.9 h	teachers' skills

Study ID	TPDP name/ format	Primary content focus	TPDP instruction type	Provider of TPDP	No. sessions/ No. hours	TPDP instruction focus
Podhajski et al. (2009)	TIME summer coursework, coaching	general reading instruction	classical and alternative	facilitators face-to-face	15 s/ 40- 45 h	teachers' knowledge and skills
Seifert et al. (2016)	LARS whole group, coaching	general reading instruction	classical and alternative	research team face-to-face	+21 s/ +17.5 h	teachers' skills
Snow et al. (2014)	OLSEL whole group	general reading instruction	classical	facilitators face-to-face	6 s/ NA	teachers' knowledge and skills
van Kuijk et al. (2016)	PDKuijk whole group	reading instruction to improve meaning-focused skills	NA	facilitators face-to-face	9 s/ 40 h	NA
Vernon-Feagans et al. (2010)	TRI summer coursework, coaching, professional learning communities	reading instruction for struggling readers	classical and alternative	facilitators face-to-face	NA/ NA	teachers' knowledge and skills
Vernon-Feagans et al. (2012)	TRI summer coursework, coaching, professional learning communities	reading instruction for struggling readers	classical and alternative	facilitators face-to-face	NA/ NA	teachers' knowledge and skills
Vernon-Feagans et al. (2013)	TRI summer coursework, online coaching	reading instruction for struggling readers	classical and alternative	facilitators blended learning	NA/ NA	teachers' knowledge and skills

3.2. The Overall Effect

We evaluated the effect of TPDP on reading outcomes for struggling readers and non-struggling readers from preparatory grade to fourth grade in general education. Initial analysis for the 17 studies indicated a non-significant effect size ($k = 17$, $d = 0.090$, $SE = 0.066$, $Z = 1.367$, $p = 0.172$, 95% CI [-0.039, 0.220]) and high heterogeneity ($Q = 69.523$, $df = 16$, $p < 0.001$, $I^2 = 76.986$). We observed that the studies of Vernon Feagans et al. (2010) and Collins et al.

(2017) were outliers and we excluded them from the final analysis. Therefore, we ran the final analysis on 15 studies, and the results still indicated a non-significant and heterogeneous effect size ($k = 15, d = 0.068, SE = 0.049, Z = 1.398, p = 0.162, 95\% \text{ CI } [-0.028, 0.164]; Q = 30.934, df = 14, p = 0.006$). The effects observed from one study to another being explained in proportion of 55% by the variations in their characteristics ($I^2 = 54.742$). Thus, in this case, TPDP had a non-significant effect on the students' reading skills.

Table no. 3. *The Overall Effect of the TPDP*

	k	Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity		
		d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	I ²
Overall effect	15	.068	.049	.002	-.028	.164	1.398	.162	30.934	14	.006 54.742

Notes: k = the number of the studies; d = the average effect size; SE = standard error of the average effect size; $Var (d)$ = variance of the average effect size; Z = the statistical test used for computing the significance of the average effect size Q = the statistical test used for evaluating heterogeneity; I^2 = the degree of inconsistency in the studies' results

3.3. The Effect for Struggling Readers Compared to non-Struggling Readers

Initial analysis for the nine studies indicated a negative significant effect size of TPDP on reading outcomes for struggling readers compared to non-struggling readers ($k = 9, d = -0.986, SE = 0.115, Z = -8.545, p < 0.001, 95\% \text{ CI } [-1.212, -0.760]$) and homogenous ($Q = 14.020, df = 8, p = 0.081, I^2 = 42.939$). We excluded the outliers and we ran the final analysis for seven studies and the results indicated a negative significant effect size ($k = 7, d = -0.937, SE = 0.126, Z = -7.462, p < 0.001, 95\% \text{ CI } [-1.183, -0.691]$) and homogenous. The effects observed from one study to another being explained in proportion of 47% of the variations in their characteristics ($Q = 11.245, df = 6, p = 0.081, I^2 = 46.641$). In this case, the struggling readers did not close the gap or reach the same level of skills as their non-struggling peers.

Table no. 4. *The Effect for Struggling Readers Compared to non-Struggling Readers*

k	Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity			
	d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	p	I ²
7	-.937	.126	.016	-1.183	-.691	-7.462	p<.001	11.245	6	.081	46.641

Notes: *k* = the number of the studies; *d* = the average effect size; *SE* = standard error of the average effect size; *Var* (*d*) =variance of the average effect size; *Z* = the statistical test used for computing the significance of the average effect size *Q* = the statistical test used for evaluating heterogeneity; *I*² = the degree of inconsistency in the studies' results

After we excluded the outliers, we could not run the supplementary analyses because we had not enough studies for each variable category. As a consequence of this, the following analyses focused only on studies that compared equivalent groups (i.e., non-struggling readers in experimental group vs non-struggling readers in control group or struggling readers in experimental group vs struggling readers in control group).

3.4. Effects Size for Distinct Grades

We identified some studies focused on preparatory grade and first grade at the primary school level ($k=7$). The results indicate a statistically non-significant and heterogeneous effect size of the TPDP on reading skills for preparatory grade and first grade ($d=0.016$, $SE=0.076$, $Z=0.205$, $p=0.838$, 95% CI [-0.133, 0.164]). The effects observed from one study to another were explained in proportion of 67% by the variations in their characteristics ($Q=18.354$, $df=6$, $p=0.005$, $I^2=67.310$) after we excluded the outlier. We ran analysis for the second grade ($k=4$) and the results indicate a non-significant and homogenous effect size ($d=0.051$, $SE=0.078$, $Z=0.660$, $p=0.509$, 95% CI [-0.101, 0.203]). The effects observed from one study to another were similar ($Q=3.096$, $df=3$, $p=0.377$, $I^2=3.090$). We identified just one study for third grade ($k=1$). Therefore, we could not evaluate the impact of TPDP on reading skills for third-grade students. We also ran analysis for the fourth grade ($k=3$), after excluding the outlier. The results indicate a statistically significant small and homogenous effect size ($d=0.201$, $SE=0.078$, $Z=2.574$,

$p = 0.010$, 95% CI [0.048, 0.354]). The effects observed from one study to another were similar ($Q = 2.634$, $df = 2$, $p = 0.268$, $I^2 = 24.072$). Therefore, we can state that TPDP have a statistically significant small effect on the reading skills for fourth grade students.

Table no. 5. *The Effects of TPDP for Distinct Grades*

Grade	k	Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity			
		d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	p	I ²
prep + 1st grade	7	.016	.076	.006	-.133	.164	0.205	.838	18.354	6	.005	67.310
2nd grade	4	.051	.078	.006	-.101	.203	0.660	.509	3.096	3	.377	3.090
4th grade	3	.201	.078	.006	.048	.354	2.574	.010	2.634	2	.268	24.072

Notes: k = the number of the studies; d = the average effect size; SE = standard error of the average effect size; $Var(d)$ = variance of the average effect size; Z = the statistical test used for computing the significance of the average effect size; Q = the statistical test used for evaluating heterogeneity; I^2 = the degree of inconsistency in the studies' results

3.5. Effects Size for Distinct Reading Skills

We investigated whether the TPDP improved code-focused skills, meaning-focused skills, or general reading skills. We analyzed the effects of the TPDP on decoding and fluency, and the results indicate a statistically non-significant effect size. We did not identify enough studies to run the analyses for phonological awareness and word identification. The analysis indicates that the TPDP have a statistically non-significant ($k = 8$, $d = 0.034$, $SE = 0.070$, $Z = 0.485$, $p = 0.627$, 95% CI [-0.103, 0.171]) and homogeneous effect size ($Q = 8.634$, $df = 7$, $p = 0.280$, $I^2 = 18.921$) on code-focused skills for students from preparatory grade to fourth grade. We analyzed the effects of the TPDP on vocabulary and comprehension and the results indicate a statistically non-significant effect size. Thus, for our sample, the TPDP had a statistically non-significant ($k = 12$, $d = 0.035$, $SE = 0.056$, $Z = 0.633$, $p = 0.527$, 95% CI [-0.074, 0.144]) and homogeneous effect size ($Q = 26.619$, $df = 11$, $p = 0.005$, $I^2 = 58.676$) on the students' meaning-focused skills. We identified just one study that measured general reading skills.

Table no. 6. *The Effects of TPDP for Distinct Reading Skills*

Outcomes	k	Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity			
		d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	p	I ²
decoding	5	-.068	.139	.019	-.341	.205	-0.487	.626	8.796	4	.066	54.524
fluency	5	-.036	.120	.014	-.270	.199	-0.299	.765	6.814	4	.146	41.299
code- focused skills	8	.034	.070	.005	-.103	.171	0.485	.627	8.634	7	.280	18.921
vocabulary	4	-.069	.070	.005	-.206	.067	-0.993	.321	6.545	3	.088	54.162
comprehension	11	.071	.066	.004	-.059	.201	1.075	.282	24.479	10	.006	59.149
meaning- focused skills	12	.035	.056	.003	-.074	.144	0.633	.527	26.619	11	.005	58.676

Notes: *k* = the number of the studies; *d* = the average effect size; *SE* = standard error of the average effect size; *Var (d)* = variance of the average effect size; *Z* = the statistical test used for computing the significance of the average effect size *Q* = the statistical test used for evaluating heterogeneity; *I*² = the degree of inconsistency in the studies' results

3.6. Moderator analyses

3.6.1. Features of TPDP

To answer our research question focused on features of TPDP that might moderate the effects on reading skills, we ran subgroup and meta-regression analyses. We aimed to explore the following features of TPDP: format of the program, format design (i.e., singular format or multiple format), instruction type, primary content focus, provider of the program, instruction focus, number of sessions, number of hours, using technology to deliver the program, theoretical foundation of the program and teachers' participation type.

We identified the following formats of TPDP: whole group, summer coursework, professional learning communities (including teacher study group), coaching, online training. We could not compare which format is more efficient and produce the highest impact on the students' reading outcomes because the majority of the TPDP used a multiple format (e.g., summer coursework and coaching). Thus, we grouped the programs in two categories: singular format and multiple

format and we analyzed if the format design of the program moderate the impact of TPDP. We analysed programs that focused on general reading skills, that aimed to improve meaning-focused skills, and focused on using technology in classroom. In other cases, the primary content focus did not vary enough across the studies to conduct analysis. The TPDP were delivered by the research team or facilitators (i.e., TPDP staff, coaches, mentors, literacy specialists, senior teachers). Furthermore, we evaluated if TPDP aimed to improve teacher knowledge, teacher skills or both. We did not identify programs that focused to improve just the teacher knowledge. As we can see in Table no. 7, the analyses showed that the format design, primary content focus, provider of the program and instruction focus did not moderate the impact of the TPDP on the students' reading outcomes.

We grouped the programs in three different categories: classical programs (whole group, summer coursework, online training), alternative programs (professional learning communities, coaching) or hybrid programs (mixt between classical programs and alternative programs). The results indicate a statistically significant small effect ($k = 12$, $d = 0.140$, $ES = 0.038$, $Z = 3.659$, $p < .001$), and heterogeneous effect ($Q = 4.313$, $df = 1$, $p = 0.038$). The analysis showed that classical programs had a statistically significant small effect size ($k = 6$, $d = 0.188$, $ES = 0.045$, $Z = 4.206$, $p < 0.001$), while hybrid programs (i.e., those programs that also include coaching, mentoring or feedback sessions) had a statistically non-significant effect size ($k = 6$, $d = 0.007$, $ES = 0.075$, $Z = 0.096$, $p = 0.924$). We identified only two alternative programs so we could not include this type of programs in the analysis.

Table no. 7. Moderator Analysis for Features of the TPDP

TPDP features	k	Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity			
		d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	p	I ²
TPDP format design	(Q _{between} (1) = 0.586, p = .444)											
Singular format	10	.089	.057	.003	-.023	.201	1.554	.120	26.657	9	.002	66.238
Multiple format	5	-.006	.110	.012	-.221	.209	-0.053	.958	4.025	4	.403	0.612

TPDP features	k	Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity			
		d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	p	I ²
TPDP instruction type		(Q _{between} (1) = 4.313, p = .038)										
Classical programs	6	.188	.045	.002	.100	.275	4.206	<.001	5.897	5	.316	15.218
Hybrid programs	6	.007	.075	.006	-.139	.153	0.096	.924	4.038	5	0.544	<.001
Primary content focus		(Q _{between} (2) = 0.022, p = .989)										
General reading instruction	4	.071	.106	.011	-.136	.279	0.674	.500	6.473	3	.091	53.651
To improve meaning-focused skills	6	.060	.073	.005	-.083	.203	0.820	.412	16.522	5	.006	69.738
Using technology in classroom	3	.079	.120	.015	-.157	.315	0.658	.511	1.434	2	.488	<.001
Provider of TPDP		(Q _{between} (1) = 0.015, p = .901)										
Research team	5	.078	.083	.007	-.084	.240	0.946	.344	13.271	4	.010	69.858
Facilitators	9	.064	.072	.005	-.077	.206	0.890	.374	17.571	8	.025	54.470
TPDP instruction focus		(Q _{between} (1) = 0.091, p = .762)										
Focused on skills	6	.049	.080	.006	-.107	.206	0.618	.537	11.723	5	.039	57.351
Focused on knowledge and skills	8	.082	.075	.006	-.064	.228	1.104	.269	19.013	7	.008	63.183

Notes: *k* = the number of the studies; *d* = the average effect size; *SE* = standard error of the average effect size; *Var (d)* = variance of the average effect size; *Z* = the statistical test used for computing the significance of the average effect size *Q* = the statistical test used for evaluating heterogeneity; *I*² = the degree of inconsistency in the studies' results

The meta-regression analysis indicates that there is a negative relationship (-0.0181, *ES* = 0.0074, *Z* = -2.45, *p* = 0.0142) between the number of sessions of the TPDP and the effect size. Table no. 8 shows that the TPDP with fewer sessions are more effective (*Q* = 6.02, *df* = 1, *p* = 0.0142).

Table no. 8. Number of TPDP Sessions

	k	95% confidence interval				Test of null (2- Tail)		Heterogeneity		
		Coefficient	SE	Lower limit	Upper limit	Z	p	Q	df (Q)	p
No. of sessions	12	-0.0181	.0074	-.0325	-.0036	-2.45	.0142	6.02	1	.0142

Notes: k = the number of the studies; SE = standard error Z = the statistical test used for computing the significance of the average effect size; Q = the statistical test used for evaluating heterogeneity;

All TPDP were delivered face-to-face, except for one blended learning program. Thus, the use of technology to deliver the TPDP did not vary enough across the studies for supplementary analysis. Besides that, we could not run additional analyses because the studies reported too few information about the theoretical foundation of the program, hours, or teacher’s participation type (voluntary based).

3.6.2. *Characteristics of Study Design*

We examined 11 randomized controlled trials and 4 quasi-experimental studies. As Table no. 9 shows, the study design did not significantly moderate the effects.

3.6.3. *Characteristics of the Intervention Context*

We aimed to analyze whether the characteristics of the intervention context could moderate the effect of TPDP on the students’ reading outcomes. Country did not vary enough across studies for moderator analysis. We identified 12 studies conducted in the United States of America, one in Australia, one in Austria, and one in the Netherlands. There was a lack of information regarding the type of school (public or private) where the studies were conducted. As Table no. 10 shows, the area (urban or rural) where the interventions were conducted did not significantly moderate the effects.

Table no. 9. Characteristics of Study Design

Study features	k	Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity		
		d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	I ²
Study design	(Q _{between} (1) = 0.704, p = .401)										
RCT	11	.088	.056	.003	-.021	.197	1.583	.113	29.112	10	.001
QED	4	-.024	.121	.015	-.261	.214	-0.196	.845	1.366	3	< .001

Notes: k = the number of the studies; d = the average effect size; SE = standard error of the average effect size; Var (d) =variance of the average effect size; Z = the statistical test used for computing the significance of the average effect size Q = the statistical test used for evaluating heterogeneity; I² = the degree of inconsistency in the studies' results

Table no. 10. Area (Urban or Rural)

k		Effect size			95% confidence interval		Test of null (2- Tail)		Heterogeneity			
		d	SE (d)	Var (d)	Lower limit	Upper limit	Z	p	Q	df (Q)	p	I²
Area		(Q _{between} (1) = 0.091, p = .762)										
Urban	5	.091	.083	.007	-.071	.253	1.106	.269	12.869	4	.012	68.918
Rural	7	.034	.084	.007	-.132	.199	0.398	.691	5.830	6	0.442	< .001

Notes: k = the number of the studies; d = the average effect size; SE = standard error of the average effect size; Var (d) =variance of the average effect size; Z = the statistical test used for computing the significance of the average effect size Q = the statistical test used for evaluating heterogeneity; I² = the degree of inconsistency in the studies' results

3.6.4. Characteristics of the Participants

Moreover, we evaluated whether the characteristics of the participants could moderate the effect of TPDP on the student's reading outcomes. We could not run additional analyses related to teachers' characteristics because the studies reported too few information about their age, teaching experience and previous

participation in TPDP in the reading domain. Also, we did not obtain enough information about the age of the students or their native language.

3.7. Publication Bias

To identify possible publication bias, we visually inspected the funnel plot. In this graphical representation, studies that reported small sample sizes are scattered at the bottom of the graph, while the studies that reported large sample sizes are scattered at the top of the graph. The x-axis shows the effect size and the y-axis shows the standard error of each study. The funnel plot graph for the 15 included studies is represented in Figure 2. In addition, we used Egger's test and the trim and fill procedure to examine the symmetry of the funnel plot. The model shows that there was no detectable publication bias. The Egger's test is statistically non-significant (intercept = 0.555; CI: -1.214, 2.324; $p = .254$ 1- tailed; $p = .509$ 2- tailed), and the trim and fill procedure indicates that no additional studies are needed to have a symmetrical funnel plot.

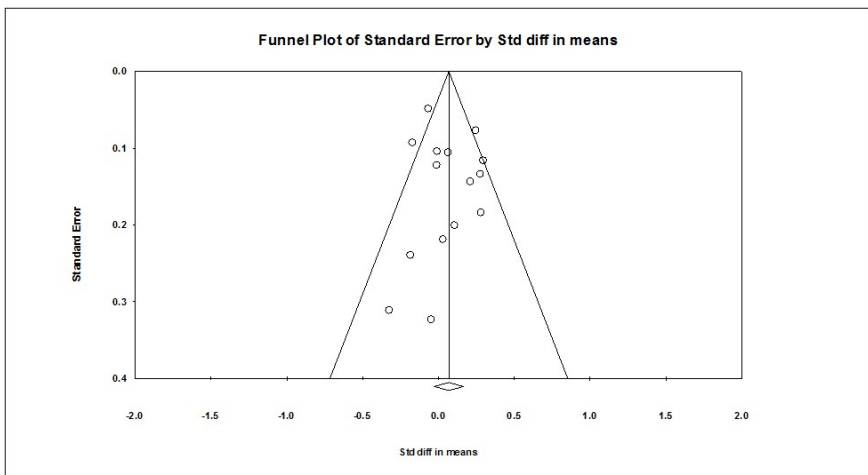


Figure no. 2. Funnel Plot

4. Discussion

4.1. Main Findings and Implications for Practice

The purpose of this meta-analysis was to determine the impact of the TPDP on the student reading skills for non-struggling readers and struggling readers from preparatory grade to the fourth grade in general education. Overall, the analysis showed that TPDP did not significantly improve the reading skills ($d = 0.068$). In contrast with our findings, Basma and Savage (2018) showed that the TPDP improve reading outcomes for kindergarten to fifth grade students ($g = 0.225$) and Didion et al. (2020) showed that TPDP improve reading outcomes for kindergarten to eighth grade students ($g = 0.18$). These results may indicate that TPDP focused on kindergarten students or fifth to eighth-grade students could be more effective than TPDP focused on primary school (i.e., prep – 4th grade). Our analysis also showed that TPDP improved reading skills for fourth-grade students ($d = 0.201$). These findings should be interpreted with caution, as we identified only three studies in two different articles that focused on fourth-grade students. These programs aimed to improve meaning-focused skills. These results could indicate that TPDP focused on meaning focused skills could be more efficient than TPDP that focused on other kind of content. On the other hand, these differences could be generated by the distinct characteristics of the students (grade, age) and different needs of the children (status – non-struggling readers or struggling readers).

In addition, our goal was to explore which are the efficient features of the TPDP that improve the student reading skills. The classical programs (whole group, summer coursework, online training) included in our analysis are more efficient ($d = 0.188$) than hybrid programs (mixed between classical programs and alternative programs that include coaching, online coaching). We identified that fewer sessions of TPDP are more effective which is similar to the results presented by previous meta-analyses focused on reading domain. For example, Basma and Savage (2018), showed that shorter TPDP with less than 30 hours produce a larger effect size compared to longer TPDP with more than 30 hours.

4.2. Limitations and Future Directions

Our purpose was also to evaluate the impact of TPDP on struggling readers compared to non-struggling readers in general education. The struggling readers did not have better results compared to non-struggling readers after their teachers participated in TPDP. Thus, questions remain about what effective features of TPDP could close the gap or help struggling readers reach the same level of skills as their non-struggling peers. In addition, our goal was to explore the impact of TPDP on teaching knowledge, teaching skills, attitudes, and perceptions of the teachers. Most included studies did not evaluate the impact on the teacher-level outcomes. Thus, questions remain about whether teaching skills could be improved, and teacher's perceptions could positively change and how these teacher-level outcomes affect the relationship between TPDP and student's reading skills.

Our analyses were limited by the lack of information about participants' characteristics or type of the school. Twelve studies were conducted in the United States of America, one in Australia, one in Austria and one in the Netherlands. Therefore, our conclusions should be interpreted with caution because the studies are limited to the TPDP from United States of America. We analyzed the design of the studies and included randomized controlled trials and quasi-experimental designs that measured the students' outcomes. Studies used a business-as-usual condition or waiting list condition to compare the effectiveness of the interventions. We excluded studies (e.g., Sailors & Price, 2010; Sailors & Price, 2015; Van Keer & Verhaeghe, 2005; Vernon-Feagans et al., 2015) that compared the experimental TPDP with an alternative TPDP format. Future research could include these studies to evaluate which TPDP format is more efficient. On the other hand, future research studies should report all the necessary data to calculate the ES. Because we did not obtain all the necessary data, we excluded several studies (i.e., Matsumura et al., 2013; McCutchen et al., 2002; Parkinson et al., 2015; Piper & Zuilkowski, 2015; Porche et al., 2012). Therefore, the future randomized control trials and quasi-experimental designs should invest more effort in the level of control and the overall quality of the research design when implementing the TPDP. Moreover, future meta-analyses should also evaluate the quality of the included studies.

4.3. Conclusion

Our current meta-analysis showed that the TPDP have a statistically non-significant general effect size on the student reading skills for non-struggling readers and struggling readers from preparatory grade to the fourth grade in general education, but a significantly small effect size in the case of fourth grade students. Moderator analyses showed that classical programs rather than hybrid programs, that also include coaching, mentoring or feedback sessions, and also a small number of program sessions are more effective and might improve the student reading skills. The struggling readers did not close the gap or reach the same level of skills as their non-struggling peers after their teachers participated in TPDP. Future research studies should report more data about the programs, participants, study design for the supplementary analyses. Future meta-analyses and systematic review are necessary to identify effective features of TPDP and the impact on the teachers' teaching skills.

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