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Article

Unpacking the Mechanism: How Professional Learning Communities Influence Primary School Teachers' Self-Efficacy

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Abstract: This paper investigates the mediation mechanisms through which professional learning communities shape primary teachers' self-efficacy in various educational systems. Based on the data from 15,847 teachers in 16 systems, a multi-level mediation analysis was conducted to test the mediation effects of teacher collaboration, professional development, and job satisfaction. Professional learning communities were measured by aggregating collaborative activity at the school level, while self-efficacy was assessed by the TALIS Teacher Self-Efficacy Scale. The study employed hierarchical linear modeling and multi-level structural equation modeling, which involved the use of bootstrap methods, to address the nested data structure. The findings show that professional learning communities had a positive total standardised effect of 0.43 on self-efficacy, where teacher collaboration was the strongest mediator (indirect effect = 45.8%), followed by job satisfaction (indirect effect = 37.5%) and professional development (indirect effect = 16.7%). The direct effect was significant at 0.19, indicating the presence of residual mechanisms. Cross-country analyses disclosed wide variations, where teacher collaboration was most pronounced in Nordic systems (0.14-0.17), while job satisfaction was most salient in East Asia (Japan = 0.16, South Korea = 0.15). The study contributes to theory by shedding more light on the mechanisms for efficacy development, while its findings can be utilised to develop culturally adapted professional learning activities to boost primary teachers' confidence by engaging them in genuine collaborative activities.

Keywords: Professional learning communities; Teacher self-efficacy; Multilevel mediation; Cross-national comparison; Primary education

1. Introduction

Teacher self-efficacy, which refers to teachers' beliefs regarding their ability to perform the actions necessary for effective teaching, was established as an important predictor of teaching effectiveness and student academic achievement [1]. For primary teachers, their self-efficacy beliefs permeate not only their teaching but also their dedication to teaching as a profession [2]. As teacher self-efficacy has been found to play a crucial role in determining the success of education, there has been great interest within the education community regarding the factors that influence these beliefs.

Professional Learning Communities (PLCs) have recently become widely recognized and adopted for teachers' professional development. Unlike the isolated form of professional learning, PLCs emphasize collaborative inquiry, collective accountability for student learning, and reflective dialogue among teachers [3]. Meta-analytic syntheses involving data from over 38,000 teachers have shown a moderate and positive correlation between PLC involvement and teachers' self-efficacy beliefs (r = 0.40) [4]. Cross-national analyses of data from the 40 countries in the Teaching and Learning

International Survey (TALIS) have also shown that PLCs predict job satisfaction in all countries and cultures, while the relationship between PLCs and self-efficacy varies in magnitude in different education settings [5]. From a theoretical perspective, PLCs can have multiple effects on teachers' self-efficacy according to Bandura's Social Cognitive Theory, which articulates four sources of efficacy development, namely, mastery experiences, vicarious experiences, social persuasion, and emotional experiences [6]. Mastery experiences can come from collaborative teaching; vicarious experiences can come from peer observations; and social persuasion can come from collegial feedback. Moreover, supportive working relations can mitigate emotional experiences. However, empirical research aiming at systematically examining the proposed theories in various education settings remains scarce [7].

Despite evidence accumulating to support the relationship between PLCs and teachers' outcomes, important aspects remain to be explored in identifying mediation processes underlying the relationship between PLCs and self-efficacy [8]. The majority of current literature is based upon direct links between PLCs and efficacy without consideration of the relationship between PLCs and efficacy other than as a "black box" [9]. Studies conducted using multilevel structural equation analysis have started to clarify such processes by identifying cognitive activation, as well as collective teacher efficacy, as mediators, although few have explored such processes at the individual level. The use of frequency of collaboration between teachers, professional development, and job satisfaction as mediators needs to be explored systematically. The findings of cross-cultural studies have shown power distance and collectivism to be important in moderating PLCs' effectiveness, suggesting processes might differ in educational settings in other countries. However, comparative studies exploring whether processes of mediation differ in other nations have been surprisingly absent in current literature [10].

The elementary education context presents a set of challenges for educators that are different from those in other educational contexts, including the need for educators to work in a variety of subjects, meet the different developmental levels of students, and navigate the complexities of the classroom environment [11]. Such contextual factors may have implications for the effectiveness of PLCs in primary schools. For instance, self-efficacy for engagement with students is a predictor of well-being in primary educators that is more sensitive than other types of efficacy beliefs [12]. Such a construct may be particularly sensitive to the implementation of collaboration practices that focus on classroom management strategies. Studies examining the implementation of PLCs in elementary education contexts have shown that collaboration practices focused on students are more effective than practices required by administrative officials [13]. However, cross-nationally comparative research examining primary educators is limited in scope and focuses largely on aggregation across educational levels [14]. The reason this is of concern is because it may be masked in terms of variations in the effectiveness of professional learning communities in elementary settings in different educational systems in relation to which mechanism is most strongly related to efficacy beliefs.

This research bridges the gaps in the literature by examining the relationship between professional learning communities (PLCs) and the self-efficacy of primary school teachers and exploring the mediating factors that support this relationship, including teacher collaboration, professional development activities, and job satisfaction. It further explores the possibility that the mediating pathways differ across nations. Using the TALIS 2024 dataset for primary education with around 16,000 primary school teachers from 16 educational systems, the research employs multilevel mediations to explain the pathways from PLCs to teacher self-efficacy. Apart from the theoretical implications for the effectiveness of PLCs in the literature, this research has implications for the design of culturally adapted PLCs that can effectively boost the efficacy beliefs of elementary school teachers.

2. Data and Methods

2.1. Data Source

This analysis uses data from the Primary Education module of the Teaching and Learning International Survey (TALIS) conducted in 2024, which is considered to be the most current international perspective available to date regarding learning environments within primary education. The TALIS 2024 Primary Education module, conducted by OECD in the academic year of 2023–2024, used a two-step stratified sampling approach to ensure representative samples of schools and teachers for each participating education system. The TALIS 2024 Primary Education module aimed at primary education teachers at ISCED Level 1 and included a total of 16 education systems located in geographically and culturally different regions worldwide. These systems include countries in both established and emerging economies, offering adequate variation in education system policies, teacher education programs, as well as primary education organizational structures to support international comparative analysis of cross-national variation in professional collaboration-teacher self-efficacy

associations. The design of this sampling plan in TALIS 2024 is based on sound methodology to support data representation in all participating education systems. In each country, schools were sampled in proportion to size, giving larger schools greater probability of selection. The next stage involved randomly selecting teachers in chosen schools to complete this international survey exercise. The two-level hierarchical structure of this sampling plan, in which teachers are clustered in schools, demands analysis strategies to address data dependencies in hierarchical data structures appropriately. Weights to support accurate inferences in population analysis were applied in all analysis to be conducted in this international evaluation exercise. The final analysis sample is primary education teachers in all 16 education systems participating in this international evaluation exercise, with response rates aligned to OECD data quality requirements for data representation in international analysis exercises.

2.2 Variable Measurement

The dependent variable in the above-mentioned study is teacher self-efficacy, which is measured using the TALIS 2024 Teacher Self-Efficacy Scale. The TALIS 2024 Teacher Self-Efficacy Scale measures teacher beliefs in carrying out key teaching tasks in the following three conceptual subscales. The Classroom Management Self-Efficacy subscale measures teacher beliefs in managing disorder in the classroom, dealing with disruptive behavior, and creating productive classroom routines. The Instructional Self-Efficacy subscale measures teacher beliefs in carrying out high-quality teaching practices, communicating content, and differentiating instruction to respond to student needs. Self-efficacy in student engagement measures perceived ability to motivate students, foster positive attitudes toward learning, and support student confidence. Teachers respond to items using a four-point scale ranging from "not at all" to "a lot," with questions such as "To what extent can you do the following?" followed by specific teaching tasks. TALIS 2024 data reveal that teacher self-efficacy is positively associated with meeting lesson aims, professional well-being, and job satisfaction after controlling for teacher and school characteristics.

The main independent variable, PLC is tapped by items that reflect collaborative professional activity at schools. The TALIS 2024 assessment does not use a scale for professional learning communities, but it uses several items to measure concepts related to PLCs by means of two validated collaboration indices. The scale for Exchange and Coordination for Teaching includes less intense collaborative activities, such as cooperating with other teachers to agree on a common standard for assessments, sharing educational materials, and discussing issues related to the development of learning for students. The scale for Professional Collaboration in Lessons includes more intense collaborative activities, which are fundamental to the theory underpinning PLCs, such as classroom observations, peer-class feedback, collaborative activities for several classes, collaborative professional learning, and team teaching. All items are measured by means of a five-point scale, which varies from "Never or Almost Never" to "Every Day or Almost Every Day." Individual teacher data for the main collaborative variables are aggregated to the school level by means of within-school averaging, and composite indicators for the collaborative professional environment are obtained for each school, according to the theoretical view that considers professional learning communities to be phenomena at the school level [3].

Three mediation variables are examined in order to provide insight into the processes through which school-level professional collaboration influences individual-level teacher self-efficacy. Though the school-level PLC variables do address the organizational collaboration culture at the school level, the individual-level mediation variables address the personal experiences and perceptions of teachers in the collaborative environment. Frequency of teacher collaboration indicates actual levels of individual teachers' engagement in collaborative activity, measured through self-reports of engagement in specified collaborative practices. Though similar TALIS items have been used in defining this variable, it has been treated as an individual-level variable addressing the personal engagement of teachers in collaborative activity rather than the collaborative environment of the school. This school-level versus individual-level differentiation allows for exploration of the relationship between the school's collaborative environment and levels of individual engagement, and its effect on self-efficacy. Participation in professional development focuses on individual teachers' engagement in collaborative approaches for professional development, measured through teachers' self-reports of engagement in specified collaborative practices such as peer observation and coaching, establishment of professional learning networks specifically for teachers, and collaborative approaches for learning and development. TALIS 2024 has incorporated new response types, which distinguish in-person, online, and hybrid modes of participation, indicating shifts in the post-pandemic context of professional learning provision. Job satisfaction measures the TALIS job satisfaction scale in its standardized form, addressing overall teachers' satisfaction with the working environment, the teaching profession, and the current working

environment. Control variables address individual-level variables of teachers (gender, age, teaching experience, and education level) and school-level variables such as school size, geographic distribution, public or private status, and percentage of disadvantaged students in the school.

2.3. Sample Description

From the analytical sample, it can be seen that there is a fair amount of variation in teacher and school characteristics across the 16 participating educational systems. Not unexpectedly given global patterns in elementary education, the preponderance of the teaching force in the elementary sector is female. The teacher population varies in terms of age, stage of career, and years of experience from pre-service teachers in their first year of teaching to those with many years of experience. The educational qualifications vary in terms of the requirements for the preparation of the teacher for the primary sector in the different systems, with bachelor's degrees as the minimum requirements in some systems and post-graduate qualifications in others. The terms of employment are largely full-time in the systems with the exception of a number of systems where they are part-time. There is considerable diversity among schools with respect to their organizational features. The size of schools varies from small rural schools with small enrollments to large urban schools with large numbers of students. The geographical locations are representative of the demographics of each system, ranging from urban, suburban, to rural locations. A vast majority of schools are publicly governed, with representation from privately administered schools. Socio-economic diversity among students is also considerable, ranging from schools with mainly disadvantaged students to schools with mainly disadvantaged students. This diversity with respect to teachers as well as schools is valuable for generalization regarding the applicability of mechanisms from professional cooperation to teacher self-efficacy beliefs.

2.4. Analytical Strategy

The analytical approach employs hierarchical techniques that are suited for the nested nature of the TALIS data, in which teachers are grouped within schools and schools are further grouped within countries. The process of the analysis involves four sequential steps. The first step involves carrying out the descriptive analyses for the various variables, such as the calculation of the mean, standard deviations, and bivariate correlations for the entire sample as well as for each participant system. The above analyses provide a preliminary indication of the distribution of professional collaboration and teacher self-efficacy in the various countries, as well as the preliminary results for the correlations of the variables of interest for the current study. The second step involves the calculation of the direct effects of professional collaboration on teacher self-efficacy using hierarchical linear modeling methods. The process involves the specification of a null model to provide an estimate of the intraclass correlation coefficient, hence establishing the amount of variance in teacher self-efficacy that is associated with the schools. Afterward, control variables are added at both teacher and school levels, followed by the addition of professional collaboration variables at the school level in an effort to estimate direct effects adjusted for compositional differences among schools.

The third analysis phase focuses on mediation in order to shed light on the processes through which professional collaboration influences teacher self-efficacy. This analysis uses multilevel structural equation modeling, which allows for the estimation of direct and indirect effects simultaneously and takes into consideration the multilevel structure of the data. Due to the fact that the variables of interest for the analysis of professional collaboration are measured at the school level, while the variables of interest for mediation and self-efficacy are measured at the teacher level, cross-level mediation analyses will be conducted. In these analyses, Level 2 predictors will forecast Level 1 outcomes through Level 1 mediators. Through mediation analysis, it will be determined if individual collaboration frequency, professional development, and job satisfaction serve as mediation processes through which school-level professional collaboration cultures exert their effects on individual levels of self-efficacy. This approach takes into consideration the premise that school-level collaborative cultures can exert effects on individual levels of collaboration behavior, professional development opportunities, and job satisfaction. Using bias-corrected bootstrapping techniques for indirect effect estimation, 5,000 resampled datasets will be used. This approach will enable the construction of confidence intervals for mediation effects. To evaluate the relative importance of the various mediation processes, the percentage of the total effect for each distinct pathway will be calculated. The fourth analytical stage examines the variation across nations through multi-group structural equation modeling. The procedure first involves testing the invariance of measurements across nations to validate the assumption that the same latent constructs are measured similarly in each educational system. Mediation models are then fitted independently for each educational system, and the significance of the variation in the values of the path coefficients across nations is assessed using Cochran's Q-statistic. The procedure further

involves comparing the values of the path coefficients across nations to identify if the strength of the direct and indirect associations differs in the national contexts and if the country-specific characteristics moderate the association of interest. The analyses make use of the sampling weights provided by TALIS to correct for the complex survey design and provide estimates for the entire population. Teacher-level weights are used to correct for the selection and non-response probabilities for selection into the study, and replicate weights are used for variance estimation through jackknife repeated replication. Missing data are treated using full information maximum likelihood estimation, where the procedure makes use of the entire data assuming the data are missing at random given the observed values. The statistical models and analyses are fitted using Mplus 8.10 for multilevel structural equation models and mediations, R software version 4.3.2 with the EdSurvey package for management of the TALIS data and the application of the weights, and additional analyses using Stata 18 [15].

3. Results

3.1. Descriptive Statistics

Table 1 presents descriptive statistics and intercorrelations among the main study variables based on data from 15,847 primary school teachers across 16 educational systems. Professional learning communities at the school level exhibited a mean of 9.87 with substantial variation, as evidenced by a standard deviation of 1.94 and a range from 5.23 to 14.61. Among the three aspects of self-efficacy, the highest mean score was in the area of classroom management (10.34) and the lowest mean score was in the area of student engagement (9.68), indicating that the primary teachers have more confidence in the area of classroom management than in the area of motivating disengaged students.

The correlation matrix reveals significant theoretical links among the variables in this study. The professional learning communities (PLC) have moderate positive correlations with the three dimensions of self-efficacy, ranging from 0.35 to 0.42. The three dimensions of self-efficacy are also moderately to strongly intercorrelated, ranging from 0.61 to 0.67. This is because the dimensions are theoretically viewed as closely related but distinctly different constructs. The frequency of teachers' collaboration has the highest correlation coefficient of 0.44 with PLCs. The correlation coefficient is lower for participation in professional development (0.31) and job satisfaction (0.28). The correlation coefficient is also lower for the teaching experience variable in relation to most of the constructs in this study. The correlation coefficient is higher (0.22) in relation to job satisfaction.

However, cross-country variation in both Professional Learning Communities (PLCs) and Teacher Self-Efficacy was large across the 16 countries involved in the study. The large ranges of values reported in Table 1 above for both PLCs (5.23 to 14.61) and Self-Efficacy (4.12 to 15.29) indicate large variability in the two constructs across countries. The variability in the two constructs is reflected in almost five standard deviations for the former and about six standard deviations for the latter; this is indicative of large variability in the two constructs. All correlations were weighted for the complex design of the study using sampling weights from the TALIS study.

Table 1. Descriptive Statistics and Correlations of Main Study Variables

Variable	M	SD	Min	Max	1	2	3	4	5	6	7
1. Professional Learning Communities (School-level)	9.87	1.94	5.23	14.61	1.00						
2. Teacher Self-Efficacy: Classroom Management	10.34	1.88	4.12	15.29	0.38**	1.00					
3. Teacher Self-Efficacy: Instruction	10.12	1.76	4.87	14.93	0.42**	0.67**	1.00				
4. Teacher Self-Efficacy: Student Engagement	9.68	1.91	4.21	14.78	0.35**	0.61**	0.64**	1.00			
5. Teacher Collaboration Frequency	9.52	2.13	3.76	15.02	0.44**	0.29**	0.33**	0.27**	1.00		
6. Professional Development Participation	9.21	2.28	2.98	14.56	0.31**	0.21**	0.26**	0.23**	0.41**	1.00	
7. Job Satisfaction	10.58	2.04	3.45	15.87	0.28**	0.37**	0.34**	0.41**	0.33**	0.19**	1.00
8. Teaching Experience (years)	16.42	10.28	1.00	42.00	0.08*	0.15**	0.19**	0.12**	0.11**	0.07*	0.22**

Note. N = 15,847 primary school teachers from 16 educational systems; All scales except Teaching Experience are standardized with SD = 2 and value of 10 at item midpoint; Correlations are weighted using TALIS sampling weights; *p < 0.05,**p < 0.01

3.2. Direct Effects of Professional Learning Communities on Teacher Self-Efficacy

The findings for the direct effects of professional learning communities on teacher self-efficacy using hierarchical linear models are shown in Table 2 below. The null model showed that 12.5% of the

variance in teacher self-efficacy was between schools, with an intraclass correlation coefficient of 0.125. The large variation between schools was enough to warrant the application of multilevel modeling, implying that variables at the school-level, such as professional learning communities, could be influential.

Table 2. Hierarchical Linear Models Predicting Teacher Self-Efficacy from Professional Learning Communities

	Predictor	Model 1: Null	Model 2: Controls	Model 3: Full Model
		β (SE)	β (SE)	β (SE)
Fixed Effects	Intercept	10.08*** (0.09)	9.84*** (0.21)	8.73*** (0.28)
Teacher-level Controls	Female		0.14* (0.06)	0.13* (0.06)
	Age		0.02 (0.01)	0.02 (0.01)
	Teaching Experience (years)		0.01* (0.00)	0.01* (0.00)
	Master's Degree or Higher		0.19** (0.06)	0.17** (0.06)
	Full-time Employment		0.23* (0.09)	0.21* (0.09)
School-level Controls	School Size (log)		0.08 (0.05)	0.06 (0.05)
	Urban Location		0.11 (0.08)	0.09 (0.08)
	Private School		0.03 (0.12)	0.02 (0.11)
	% Low SES Students		-0.02** (0.01)	-0.01* (0.01)
PLC Dimensions	Exchange & Coordination (T3EXCH)			0.18** (0.06)
	Professional Collaboration (T3COLES)			0.31*** (0.07)
Variance Components	Level 1 (Teacher)	2.87	2.69	2.64
	Level 2 (School)	0.41	0.29	0.21
	ICC	0.125		
Model Fit	Deviance	68,234.5	67,891.3	67,542.8
	AIC	68,240.5	67,915.3	67,552.8
	BIC	68,263.2	67,982.7	67,631.4
	R^2 Level 1		0.063	0.080
	R^2 Level 2		0.293	0.488

Note. N = 15,847 teachers in 1,246 schools across 16 educational systems; All models use TALIS sampling weights and account for complex survey design; β = standardized coefficient; SE = standard error; ***p < 0.001, **p < 0.01, *p < 0.05; ICC = Intraclass Correlation Coefficient; Deviance, AIC, and BIC are model fit indices (lower values indicate better fit); R2 Level 1 represents variance explained at teacher level; R2 Level 2 represents variance explained at school level

Model 2 included control variables at the teacher level and the school level. Various teacher characteristics had strong significance to self-efficacy. Female teachers had marginal levels of self-efficacy than males, with a standardized coefficient of 0.14. Individuals with master's degrees or higher had significantly higher self-efficacy than people with only bachelor's degrees. Full-time work had a strong association with self-efficacy, although it had small effect size. The relationship between experience and self-efficacy was small but significantly positively related to self-efficacy, consistent with findings indicating that confidence is accumulated over career long periods of time. At the institutional level, the number of students from low socio-economic background had small negative association to self-efficacy, suggesting teachers in institutions with more students from low socio-economic background had slightly low self-efficacy. Institutional size, urban status, and public vs. private status had no significance to self-efficacy after other variables were controlled in the model. The inclusion of control variables decreased between-school variation from 0.41 to 0.29, accounting for nearly 29% variation between schools.

Model 3 included two facets of PLCs as school-level variables. Both facets of PLCs had statistically significant positive relationships with teacher self-efficacy, although their strengths differed considerably. Professional collaboration in classrooms had a stronger impact, with a standardized coefficient of 0.31, while exchange and coordination of teaching had a weaker, although still significant, impact of 0.18. These findings indicate that more deep-seated collaboration activities, such as peer teaching, team teaching, and joint professional development activities, have a stronger impact on teacher confidence than more shallow collaboration activities, such as exchanging teaching materials or aligning assessment criteria. Adding the PLC variables accounted for an additional 28% of variance in

teacher self-efficacy at the school level, reducing between-school variance from 0.29 to 0.21. The full model accounted for 8.0% of teacher-level variance and 48.8% of school-level variance in self-efficacy. Model fit indices showed progressive improvement across models, with the full model demonstrating the lowest deviance, AIC, and BIC values, confirming that professional learning communities contribute meaningfully to explaining variation in teacher self-efficacy beyond individual teacher characteristics and basic school demographics.

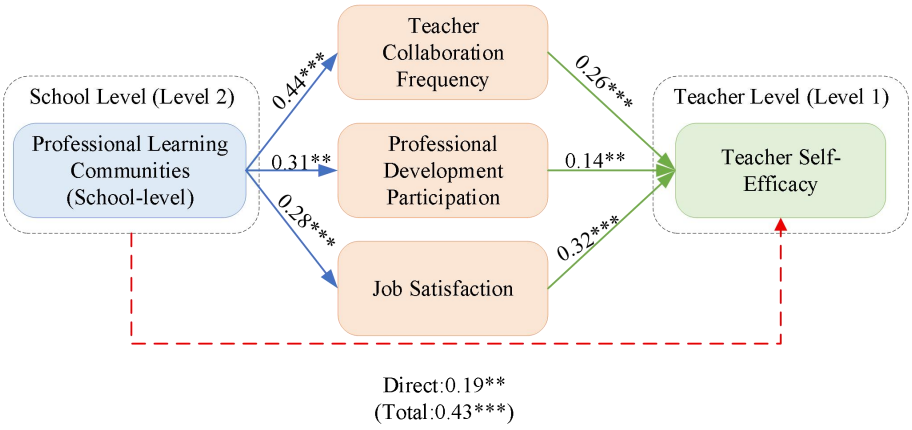
3.3. Mediation Analysis

Table 3 presents results from multilevel mediation analyses examining the mechanisms through which professional learning communities influence teacher self-efficacy. Figure 1 illustrates the complete mediation model with standardized path coefficients. Analysis employed cross-level mediation models in which school-level PLC variables were predictors of teacher-level outcomes through teacher-level variables, and all three mediation paths were examined simultaneously. Using the confidence intervals of 5,000 resamples, bootstrapping techniques were used in the analysis to provide accurate indirect effects.

Table 3. Multilevel Parallel Mediation Analysis Results

	Pathway	Path	β	SE	95% CI	P
Paths from PLC to Mediators (a paths)	PLC → Teacher Collaboration	a_1	0.44	0.08	[0.28, 0.60]	<0.001
	PLC → Professional Development	a_2	0.31	0.09	[0.13, 0.49]	0.001
	PLC → Job Satisfaction	a_3	0.28	0.08	[0.12, 0.44]	<0.001
Paths from Mediators to Self-Efficacy (b paths)	Teacher Collaboration → Self-Efficacy	b_1	0.26	0.04	[0.18, 0.34]	<0.001
	Professional Development → Self-Efficacy	b_2	0.14	0.05	[0.04, 0.24]	0.006
	Job Satisfaction → Self-Efficacy	b_3	0.32	0.04	[0.24, 0.40]	<0.001
Direct and Indirect Effects	Direct Effect (PLC → Self-Efficacy, controlling for mediators)	c'	0.19	0.06	[0.07, 0.31]	0.002
	Indirect Effect via Teacher Collaboration	a_1b_1	0.11	0.03	[0.06, 0.18]	<0.001
	Indirect Effect via Professional Development	a_2b_2	0.04	0.02	[0.01, 0.09]	0.021
	Indirect Effect via Job Satisfaction	a_3b_3	0.09	0.03	[0.04, 0.15]	0.001
	Total Indirect Effect	—	0.24	0.04	[0.17, 0.32]	<0.001
	Total Effect (PLC → Self-Efficacy)	c	0.43	0.07	[0.30, 0.56]	<0.001

Note. N = 15,847 teachers in 1,246 schools; All models control for teacher and school characteristics; β = standardized coefficient; SE = standard error; 95% CI = bias-corrected bootstrap confidence interval based on 5,000 resamples; All three mediators tested simultaneously in a parallel mediation model; Direct effect represents the path from PLC to Self-Efficacy when controlling for all three mediators; Total effect = Direct effect + Total indirect effect (0.19 + 0.24 = 0.43).



Note. N = 15,847 teachers in 1,246 schools; Standardized path coefficients are shown on arrows; ***p < 0.001, **p < 0.01; Solid arrows represent mediation pathways, dashed arrow represents direct effect; Total effect = Direct effect + Indirect effects

Figure 1. Path Diagram of Multilevel Mediation Model with Standardized Coefficients

Frequency of teacher collaboration was found to be the strongest mediator with an indirect effect of 0.11, which explains 45.8% of the total indirect effect. Those schools with strong collaborative cultures had teachers who participated individually in collaborations to a greater extent, which predicted their strong self-efficacy beliefs. This finding shows that collaboration within the organization is channeled into actual behavioral engagement, which provides teachers with mastery experiences and vicarious learning opportunities that enhance their efficacy beliefs. This finding is consistent with social cognitive theory, which suggests that enactive mastery is the strongest source of efficacy information.

Job satisfaction served as a secondary mediator, with an indirect effect of 0.09, accounting for 37.5% of the total indirect effect. Professional learning communities positively impacted teachers' workplace satisfaction, which in turn led to increased self-efficacy beliefs. The findings suggest that professional learning communities help to foster more conducive work settings, while the positive affect tied to job satisfaction might help to strengthen feelings of competence in teachers. These teachers might be more persistent in situations of challenge, leading to more success experiences, thereby strengthening self-efficacy beliefs.

In professional development participation, the mediating role was the weakest among the mediating factors, with an indirect effect of 0.04 that explained 16.7% of the total indirect effect. Despite the positive relationship between PLCs and collaborative professional learning activities, the mediating role explained less variance than other mediating processes. The relatively low mediating role may be attributed to the quality of the learning activities due to the fact that the TALIS measures focus on the frequency of participation and not the content and relevance of the activities. Additionally, the application of the learned knowledge and the observation of the impact of the activities on students may take time and cannot be explained by the cross-sectional design.

A significant direct effect of 0.19 remained between PLCs and teacher self-efficacy after accounting for all mediating pathways, representing 44.2% of the total effect. This persistent direct effect indicates that professional learning communities influence teacher confidence through additional mechanisms not captured by the measured mediators. Possible unmeasured pathways include collective teacher efficacy, organizational trust, reduced isolation, and enhanced stress management. As shown in Table 4, the three measured mediators together explained 55.8% of the total effect through indirect pathways. Pairwise comparisons revealed that teacher collaboration mediated significantly more than professional development, though differences between collaboration and job satisfaction were not statistically significant, suggesting caution in over-interpreting the ranking of mediators.

Table 4. Comparison of Indirect Effects Across Three Mediating Pathways

Mediator	Indirect Effect (ab)	SE	95% Bootstrap CI	Ranking	% of Total Indirect Effect
Teacher Collaboration	0.11***	0.03	[0.06, 0.18]	1	45.8%
Job Satisfaction	0.09***	0.03	[0.04, 0.15]	2	37.5%
Professional Development	0.04*	0.02	[0.01, 0.09]	3	16.7%
Total Indirect Effect	**0.24***	**0.04**	**[0.17, 0.32]**		**100%**
Direct Effect (PLC → Self-Efficacy)	0.19**	0.06	[0.07, 0.31]		
Total Effect	**0.43***	**0.07**	**[0.30, 0.56]**		
Proportion of Total Effect Mediated					**55.8%**

Note. All three mediators were tested simultaneously in a parallel multilevel mediation model; Bootstrap estimates based on 5,000 resamples using bias-corrected confidence intervals; ***p < 0.001, **p < 0.01, *p < 0.05; Pairwise contrasts show Teacher Collaboration mediates significantly more than Professional Development (Δab = 0.07, 95% CI [0.02, 0.13], p = 0.008), but the difference between Teacher Collaboration and Job Satisfaction (Δab = 0.02, 95% CI [−0.03, 0.07], p = 0.412) and between Job Satisfaction and Professional Development (Δab = 0.05, 95% CI [−0.01, 0.11], p = 0.091) were not statistically significant

3.4. Cross-National Variation in Mediation Mechanisms

Measurement invariance testing was conducted prior to cross-national comparisons to ensure that constructs were measured equivalently across the 16 educational systems. Table 5 presents fit indices for successive levels of invariance. Configural invariance was supported with acceptable fit (CFI = 0.951, RMSEA = 0.046), confirming that the same factor structure held across all countries. Metric invariance had a very small change in fit (ΔCFI = -0.003), whereas the change in fit for the full scalar invariance (ΔCFI = -0.011) violated the acceptable criteria. On the other hand, the change in fit for the

partial scalar invariance (ΔCFI = -0.003), which allowed the constraints on five items that showed large cross-national differences to be estimated freely, met the acceptable criteria.

Table 5. Measurement Invariance Testing Across 16 Educational Systems

Model	χ^2	df	CFI	TLI	RMSEA	SRMR	Comparison	$\Delta\chi^2$	Δdf	p	ΔCFI
Configural Invariance	4,126.89	1,248	0.951	0.944	0.046	0.042	-	-	-	-	-
Metric Invariance	4,318.45	1,344	0.948	0.943	0.045	0.044	vs. Configural	191.56	96	<0.001	-0.003
Scalar Invariance	4,897.23	1,440	0.937	0.934	0.048	0.051	vs. Metric	578.78	96	<0.001	-0.011
Partial Scalar Invariance	4,512.67	1,416	0.945	0.941	0.046	0.047	vs. Metric	194.22	72	<0.001	-0.003

Note. N = 15,847 teachers across 16 educational systems; χ^2 = chi-square statistic; df = degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual; $\Delta\chi^2$ = chi-square difference test; ΔCFI = change in CFI; Configural invariance tests whether the same factor structure holds across countries; Metric invariance constrains factor loadings to be equal; Scalar invariance additionally constrains item intercepts; Partial scalar invariance releases constraints on 5 items with substantial cross-national differences; Following established criteria, ΔCFI < 0.010 supports invariance; Full scalar invariance was not supported (ΔCFI = -0.011), but partial scalar invariance was acceptable (ΔCFI = -0.003), indicating sufficient measurement equivalence for cross-national comparisons

Results for country-specific estimates of the direct and indirect effects are presented in Table 6. The total effect of (PLCs on teacher self-efficacy was positive and significant in all 16 systems with values ranging from 0.38 to 0.48 and a pooled value of 0.43. This provides strong support for the idea that professional learning communities boost teacher confidence in general. However, the results for the heterogeneity tests suggest the existence of significant variation in both the direct and specific mediating paths.

Table 6. Cross-National Comparison of Direct and Indirect Effects

s	N	PLC → SE (Direct) β (SE)	Indirect via TC β (SE)	Indirect via PD β (SE)	Indirect via JS β (SE)	Total Effect β (SE)
Australia	986	0.22** (0.08)	0.12** (0.04)	0.05 (0.03)	0.08* (0.04)	0.47*** (0.09)
Czech Republic	1,024	0.11 (0.09)	0.10* (0.04)	0.04 (0.03)	0.13** (0.04)	0.38** (0.10)
Denmark	891	0.16* (0.09)	0.14** (0.05)	0.08* (0.03)	0.10* (0.04)	0.48*** (0.10)
England	1,134	0.24** (0.08)	0.09* (0.04)	0.03 (0.03)	0.06 (0.04)	0.42*** (0.09)
Finland	876	0.14 (0.09)	0.16*** (0.05)	0.03 (0.03)	0.11** (0.05)	0.44*** (0.10)
France	1,087	0.27** (0.08)	0.07 (0.04)	0.02 (0.03)	0.05 (0.04)	0.41*** (0.09)
Iceland	743	0.09 (0.11)	0.13** (0.05)	0.09* (0.04)	0.14** (0.05)	0.45*** (0.11)
Japan	1,056	0.17* (0.08)	0.06 (0.04)	0.04 (0.03)	0.16*** (0.04)	0.43*** (0.09)
Latvia	798	0.12 (0.10)	0.14** (0.05)	0.06 (0.04)	0.12* (0.05)	0.44*** (0.11)
New Zealand	1,021	0.23** (0.08)	0.10* (0.04)	0.04 (0.03)	0.09* (0.04)	0.46*** (0.09)
Norway	934	0.15* (0.09)	0.15*** (0.05)	0.08* (0.03)	0.10* (0.04)	0.48*** (0.10)
Singapore	1,198	0.21** (0.08)	0.08* (0.04)	0.07* (0.03)	0.08* (0.04)	0.44*** (0.09)
South Korea	1,067	0.16* (0.08)	0.07 (0.04)	0.05 (0.03)	0.15*** (0.04)	0.43*** (0.09)
Spain	1,143	0.21** (0.08)	0.11* (0.04)	0.05 (0.03)	0.09* (0.04)	0.46*** (0.09)
Sweden	856	0.12 (0.10)	0.17*** (0.05)	0.05 (0.03)	0.12** (0.05)	0.46*** (0.11)
United States	1,033	0.26** (0.08)	0.09* (0.04)	0.04 (0.03)	0.07 (0.04)	0.46*** (0.09)
Pooled Sample	15,847	0.19 (0.06)	0.11* (0.03)**	*0.04 (0.02)**	0.09* (0.03)**	0.43* (0.07)**
Range		0.09-0.27	0.06-0.17	0.02-0.09	0.05-0.16	0.38-0.48

Note. β = standardized coefficient; SE = standard error; ***p < 0.001, **p < 0.01, *p < 0.05; All models control for teacher and school characteristics; TC = Teacher Collaboration; PD = Professional Development; JS = Job Satisfaction; Direct effects represent the path from PLC to self-efficacy controlling for all three mediators; Indirect effects estimated using multilevel structural equation modeling with bootstrap confidence intervals (5,000 resamples); Total effect = Direct effect + Sum of indirect effects; Countries ordered alphabetically; Heterogeneity tests indicate significant cross-national variation in direct effects (Q = 41.23, p < 0.001), indirect effects via teacher collaboration (Q = 48.67, p < 0.001), and indirect effects via job satisfaction (Q = 32.45, p = 0.006). Indirect effects via professional development showed no significant heterogeneity across countries (Q = 18.34, p = 0.246).

Direct effects ranged from 0.09 in Iceland to 0.27 in France, with 11 of 16 countries reaching

statistical significance. The greater direct effects in France, the US, and England indicate that there are possibly other mechanisms at work in these systems in addition to those already measured in the way in which professional learning communities (PLCs) work. In contrast, five countries in the North and East of Europe had non-significant direct effects, which indicate that the mediating variables have a greater part in explaining the relationship in these systems.

Collaboration between teachers showed marked variation, with large indirect effects in 13 of the 16 systems, although their size varied from 0.06 in Japan to 0.17 in Sweden. The mediation effect is strongest in Nordic systems, where collaboration is institutionalized in flattened hierarchical structures to facilitate peer learning. The smaller effects in East Asian systems might be due to education systems in which hierarchical relationships and whole-school activities have more impact than collaboration in building efficacy.

Professional development had the weakest mediating influence, and there were significant effects in only 4 out of 16 countries. This was applicable only to the Nordic countries and Singapore, which indicated intense efforts being made in these countries to ensure high-quality professional development. The lack of significance in 12 out of 16 countries indicates that there are issues in professional development that are designed to increase teacher capability and, in turn, their self-belief.

Job satisfaction had high levels of consistency, producing significant coefficients in 13 out of 16 systems. The countries in the East Asian region had high levels of mediation, particularly in Japan, at 0.16, and in South Korea, at 0.15, probably because these countries tend to be collectivist, prioritizing harmony in the workplace as part of professional roles. The systems in the West European region had diverse patterns.

4. Discussion

This research examines the processes by which PLCs affect primary school teachers' self-efficacy beliefs in 16 educational systems, using data from TALIS 2024. The findings confirm previous research on the PLCs-efficacy connection and demonstrate considerable international differences in the underlying processes of this connection. The moderate and positive connection found in the current research between PLCs and teacher self-efficacy is in agreement with current meta-analytical research synthesizing the views of over 38,000 teachers, which found a correlation of 0.40 between professional learning communities and teachers' efficacy beliefs [4]. In addition to confirmation, the current research contributes to the literature in that it: (a) specifies the underlying processes of the PLCs-efficacy connection, and (b) shows the extent of international differences in these underlying processes.

That teacher collaboration was the strongest mediator is consistent with theoretical views that see the enhancement of self-efficacy as the result of mastery experiences [6]. he most recent experimental results from intervention studies attempting to increase teacher self-efficacy suggest that collaborative involvement in professional development activities has been very successful with high standardization values over 0.60 [16]. Further cross-national studies suggest that this mediator has particular potency in the Scandinavian educational system where the organizational hierarchy is flat and encourages in-depth collaboration. Such specificity supports other comparative studies that identify essential differences between Eastern and Western collaboration styles [17], suggesting that professional learning communities may need to adapt to the local culture instead of generalization. The relatively weaker mediator for professional development involvement is consistent with the finding that while professional learning communities are strongly linked with job satisfaction in different educational systems worldwide, the strength of the association with teacher learning outcomes varies [5].

The persistent direct effect, explaining 44% of the total relationship between professional learning communities (PLC) and efficacy, suggests that residual processes deserve further study. The investigation of collective teacher efficacy and organizational trust as concomitant mediators in the relationship between school characteristics and teacher outcomes proposes some promising avenues for further research [18]. The result that job satisfaction is a significant mediator, especially in East Asian settings, builds on very recent longitudinal data showing that workplace satisfaction forecasts subsequent self-efficacy rather than simply relating to it [19]. This pattern of results flies in the face of traditional notions and points to the critical role of affective mediational links through which school cultures impact teachers' confidence. Investigations of creative self-efficacy as further mediators in the relationship between PLCs and innovation on the part of teachers offer conceptual models through which efficacy in particular domains may be explored as accounting for additional variance in the relationship between PLCs and efficacy [20].

There are several limitations in these results that can be addressed in future studies. The cross-sectional nature of the data does not allow for the examination of causality in terms of the direction of relationships between variables. Even though the theoretical foundation suggests that PLCs shape self-efficacy through mediating variables, other possible configurations of causality could also

exist. Longitudinal studies following teachers over several time points could provide more convincing evidence about the direction of causality and the existence of precedence in time [21]. The use of self-report data could lead to common method variance problems, but the hierarchical structure of the data and the inclusion of aggregate-level variables can alleviate these problems. The operationalization of Professional Learning Communities via teacher perceptions of collaborative activities, which has theoretical and empirical support, could also lack the complexity of these organizations in their actual structure and function in schools [22]. Future studies using mixed-methods techniques could combine self-report data with observations of collaborative intensity and quality.

The fact that this study concentrated on primary education for 16 education systems limits generalization for secondary settings or other countries that will not be part of TALIS 2024. The cultural dimensions, power distance, collectivism, or teacher autonomy traditions, that could affect the functioning of professional learning community (PLC) processes, were only described, not analyzed, in this study [23]. Theoretical development could be achieved by using multilevel moderation models for testing cultural dimensions as moderation variables. Exploring other mediating variables, such as teacher efficacy, professional identity, or capacity for reflective practice, would be a major area for future studies [24]. Experiments that would manipulate PLC variables, using controlled or quasi-experimental designs, would provide stronger causal evidence than correlational studies [25]. Such studies could determine the most effective combinations of cooperative approaches for different settings, while exploring if enhancement of certain mediating variables would have a cumulative effect on teacher self-efficacy. Exploratory qualitative studies for understanding the subjective experience of teachers participating in professional learning communities would reveal the phenomenological details of how cooperative approaches could be converted into teacher confidence enhancement [26]. Such micro-processes could be useful for designing professional development programs that would target strategic intervention points for the functioning of cooperative approaches for teacher capacity building [27].

5. Conclusion

This paper investigates the mediating processes through which professional learning communities (PLCs) affect the self-efficacy of primary school teachers, using TALIS 2024 data with 15,847 teachers in 16 education systems. The results of multilevel mediation analyses show that PLCs have a standardized total effect of 0.43 on teacher self-efficacy. For mediating effects, teacher collaboration stands out as the largest mediator (indirect effect = 0.11, accounting for 45.8% of the total effect), followed by job satisfaction (indirect effect = 0.09, 37.5%) and professional development participation (indirect effect = 0.04, 16.7%). The residual direct effect of 0.19 implies that PLCs affect self-efficacy through other processes that were not investigated.

Cross-national findings show considerable differences in mediation effects for different education systems. More specifically, collaboration appears as the strongest mediator in the Nordic countries (values range from 0.14 to 0.17), while job satisfaction has the strongest effect in East Asia (Japan = 0.16, South Korea = 0.15). Mediational effects for professional development will remain statistically significant only in those education systems where considerable resources have been invested in practice-related professional development. Taken together, the findings of this study can improve theories of efficacy development and provide practical implications for developing culturally sensitive professional development programs. Future research should explore longitudinal processes and add additional variables such as collective efficacy and trust in the organization.

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