Impact of school leadership on teacher professional collaboration: evidence from multilevel analysis of Taiwan TALIS 2018

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Abstract

Purpose – This study examined the impact of school leadership on teacher professional collaboration, with collective teacher innovativeness and teacher self-efficacy (TSE) playing the mediating role. Two most commonly used leadership styles, instructional leadership (IL) and distributed leadership (DL), were analyzed using a multilevel design, i.e. teachers are nested within schools.

Design/methodology/approach – The proposed model was validated using data of Taiwan TALIS 2018 collected from both teachers and principals and analyzed using hierarchical linear modeling.

Findings – Results showed that IL and DL influence teacher professional collaboration through different paths. IL had a significant direct impact on teacher professional collaboration alone, while DL had a significant direct impact on both teachers' collective innovativeness and their professional collaboration. While TSE had a direct effect on collective teacher innovativeness, TSE and collective teacher innovativeness had a direct effect on teacher professional collaboration.

Originality/value – This study highlights the significant impact of principal leadership as both principals and teachers work in the same environment and culture co-shaped through the interaction and collaboration. Research evidence regarding the effects of IL and DL on teacher professional collaboration is limited; this is even less evidential when the indirect effects of variables mediating between school leadership and teacher outcomes, including teacher collective innovativeness and TSE, are added to the total effects. The present findings provide useful references for principals and teachers when promoting professional collaboration to achieve desired outcomes in school and student improvement.

Keywords TALIS 2018, Teacher professional collaboration, Instructional leadership, Distributed leadership, Teacher self-efficacy, Collective teacher innovativeness

Paper type Research paper

Introduction

In recent decades, professional collaboration has been much emphasized, particularly in the field of education. Not only is professional collaboration a vital feature of educational effectiveness, it is also considered essential to success in educational reform (Datnow, 2018). Moreover, results from the Teaching and Learning International Survey (TALIS) 2013 revealed that high-performing countries on international assessments such as Finland, Canada and Singapore have committed resources for teachers to collaborate and considered professional collaboration crucial in the educational context (OECD, 2014; Schleicher, 2016). While professional collaboration might not be the panacea, it is one of the most empirically supported and practical strategies for school improvement as well as teacher development (Hargreaves and

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O'Connor, 2017). In Taiwan, following the promulgation of the Curriculum Guidelines of the 12-Year Basic Education (Ministry of Education, 2019), the "Teacher Course Teaching and Assessment Collaboration Center" was set up with the aim to improve both the curriculum and teaching in Taiwan through connection, integration and professional collaboration among teachers (Ministry of Education, 2018). With education shifting to an emphasis on learning skills, student-centered instruction and collective learning, school leadership rests not only on principals but also teachers. On the one hand, teachers are encouraged to participate in school decision-making; on the other hand, they are also urged to collaborate and engage in professional dialog to develop school-based curriculum (Pan et al., 2017).

Professional collaboration involves individuals coming together, committing to the sharing of expertise and thinking, planning, deciding and acting based on a shared understanding of each other and the communities people operate in (John-Steiner et al., 1998; Cilliers, 2000). In terms of teacher professional collaboration, teachers have designed curriculum together, moderated each other's assessments, undertaken action research and become involved in educational networks of teachers or schools (Hargreaves and O'Connor, 2017). Collaborative professionalism emerges from the bringing together of structure and culture, as well as of formality and informality (Hargreaves, 2019).

As pointed out by Hargreaves and O'Connor (2017), teaching is an occupation or form of work that is performed in a particular way by a group or a collectivity of individuals. As social contexts evolve, so do the role people expect education to play; hence, both teachers and schools need transformation to meet changing demands in changing times (Campbell, 2020). Globally and historically, public school teaching has its root in a culture of individualism that has, in more developed and higher performing countries, begun to shift towards cultures of professional collaboration (Hargreaves and O'Connor, 2017). In view of these changes, teacher professional collaboration is taken as an outcome variable to be examined in this study.

Prior studies have identified teachers' self-efficacy and collective innovativeness as essential factors for improving the overall impact and effectiveness of professional collaboration in education (Voelkel and Chrispeels, 2017; Thomas et al., 2019). Blömeke et al. (2021) found significant and positive association between teacher collaboration and school innovativeness; and that more innovative schools delivered better outcomes. The empirical investigation of Goddard et al. (2007) observed enhancement in professional collaboration through teachers' collective innovation that requires teachers to discuss together and to share unique insights with each other, which in turn strengthens their participation in achieving common goals. Marshall and Rendall (2020) also reported a positive association between frequent professional collaboration and teacher self-efficacy (TSE). In view of these findings, this study takes collective innovativeness and TSE as research variables for further exploration.

Whether different principal leadership styles will have different effects on assorted teacher outcomes and whether school culture, structure and climate will affect teacher outcomes remain inconclusive (Liu et al., 2021b). The systematic review of Gumus et al. (2018) found distributed leadership (DL) and instructional leadership (IL) to be the two most frequently studied leadership models in educational research. Different from other leadership styles, IL emphasizes teaching and learning (Marks and Printy, 2003); while the focus of DL is group decision-making by staff at multiple levels instead of by a single individual, usually the principal (Harris, 2009). Previous studies have found positive and significant relationships of DL with teacher collective innovativeness, TSE and professional collaboration (O'Shea, 2021; Sun and Xia, 2018; Lin, 2022). Research evidence regarding the effects of IL and DL on teacher professional collaboration is limited; it is even less evidential when the indirect effects of variables mediating between school leadership and teacher outcomes, including teacher collective innovativeness and TSE, are added to the total effects. Filling this knowledge gap is the main goal of this study.

Understanding how principals lead to achieve school goals would enrich the literature on the role of leadership in educational reform and school improvement. With a model proposed for this study, the impact of school leadership styles on teacher collective innovativeness, TSE and professional collaboration was explored empirically using the survey data from TALIS 2018. The present research further examines the relationships of teacher collective innovativeness with TSE and of TSE with professional collaboration. The contribution of this study lies in providing more comprehensive and detailed evidence for the above relationships, which would be useful references for principals and teachers when promoting professional collaboration to achieve desired outcomes in school and student improvement.

Literature review and hypotheses
Conceptual framework
School leadership makes a significant difference to student outcomes (Robinson and Gray, 2019). The more leaders focus their professional relationship, work and learning on both teaching and learning, the greater their influence on student outcomes (Robinson *et al.*, 2008). Datnow and Park (2019) evidenced qualitatively the importance of school leaders in fostering cultures of collaboration. They positioned school leaders as key sensemakers with the meaning of collaboration being socially constructed. Following the framework of Datnow and Park (2019), Weddle (2022) explored how school leaders frame collaboration in schools under pressure to improve student performance and found that fostering effective collaborative cultures remained challenging even in schools with increasingly teacher-led collaboration.

As mentioned by Donohoo (2017), schools' staff working together for the greater good of the students can help boost student achievement. Teacher collective efficacy represents a shared belief among individual teachers that their collaborative efforts can enhance student academic success (Goddard *et al.*, 2000, 2004). Teachers with high efficacy show greater effort and persistence, willingness to try new teaching approaches and attend more closely to struggling student needs (Donohoo, 2017).

Figure 1 shows the conceptual framework for the present study, in which IL and DL are independent variables with direct effects on collective teacher innovativeness, TSE and teacher professional collaboration as suggested in existing literature. In addition, collective teacher innovativeness and TSE are also taken as predictors of teacher professional collaboration (Blömeke *et al.*, 2021; Marshall and Rendall, 2020). TSE has been found to have a direct impact on collective teacher innovativeness (Zainal and Matore, 2019). Prior studies have evidenced relationships between these individual variables which were rarely examined together in the same study. To fill this research gap, this investigation explores the
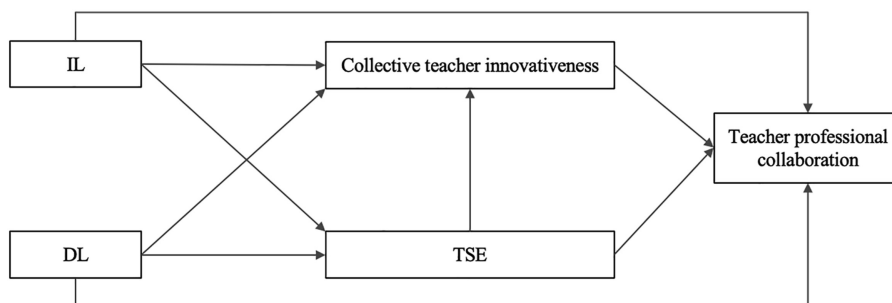
Source(s): Figure created by authors

relationships among principal leadership, teacher collective innovativeness, TSE and teacher professional collaboration at multiple levels.

Teacher professional collaboration. For any educational reform to succeed, collaboration among teachers is indispensable (Brownell *et al.*, 1997). In a broad sense, professional collaboration is defined as the collaborative interaction of a professional team in the activities required to achieve a common goal (Brouwer *et al.*, 2012). Hence, professional collaboration among teachers refers to their collective engagement in lesson planning and problem-solving, and their sharing of knowledge, perspectives and teaching strategies with one another to generate innovative instructional practices (Lomos *et al.*, 2011). Not only is professional collaboration a prominent feature in contemporary approaches to educational change (Eddy-Spicer, 2011), it is also an important medium for teacher learning (Brownell *et al.*, 2006) and a significant support for teachers to work in challenging environments (OECD, 2020). Working in a professionally collaborative environment can empower teachers with a collective capacity to initiate and sustain continuous improvement in their professional practice so that each student they teach receives the highest quality of education possible (Pugach and Johnson, 2002). Professional collaboration, besides offering teachers chances to learn, also supports them in addressing the challenges and complexities of teaching (Darling-Hammond, 2010).

As mentioned in Goddard *et al.* (2007), professional collaboration denotes a diverse assortment of activities carried out inside educational institutions. These collaborative activities can be on a one-time basis or intensive and frequent (Vangrieken *et al.*, 2015), aiming to enhance education quality provided to a single pupil, the whole classroom and the entire school (Meirink *et al.*, 2010). The positive impact of professional collaboration on school improvement, reducing inequalities and enhancing student experiences and attainment has been well documented (Muijs *et al.*, 2011). The Organization for Economic Co-operation and Development (OECD) (OECD, 2019) grouped the professional collaboration activities of teachers into four categories, namely collaborative teaching, learning by observation, cross-class teaching and community participation.

Relationship of IL and DL with teacher professional collaboration. IL. With growing popularity of IL, many countries have encouraged their principals to adopt it (Hallinger, 2018), and it was also recognized by the OECD and incorporated into their assessment survey on principal effectiveness (Bellibaş, 2015). In short, IL refers to principals observing teachers' instructional practices in classrooms, supporting collaboration among teachers in the development of new teaching approaches, ensuring teachers to take responsibility for students' learning outcomes (Bellibaş *et al.*, 2020) and providing parents with relevant information about school and student achievement (OECD, 2014).

Specific IL behaviors of principals include monitoring and evaluating teacher instructional performances according to the school vision and goals, supporting and promoting collaboration among teachers and providing resources for professional development (Brieve, 1972). Empirical research has evidenced a relationship between IL and teacher professional collaboration in that effective IL fosters teamwork and cultivates a culture of collaboration by establishing trust and creating structures that promote teacher learning (Youngs and King, 2002), which is also related to collaboration in innovative teams (Meirink *et al.*, 2010). Thus, it can be inferred that IL of principals affects teacher professional collaboration. Moreover, Webs and Holtappels (2018) found that to carry out more demanding teacher professional collaboration would require IL of principals in addition to self-efficacy of teachers. However, direct empirical evidence on the relationship between IL and teacher professional collaboration is scarce. In view of the above, the following hypothesis is proposed.

H1. IL is significantly and positively related to teacher professional collaboration.

DL. Within education, the enormous accountability pressure has made the tasks, roles and responsibilities of principals become increasingly complex and beyond the capability of any single individual (Hartley, 2007). Such has undermined the traditional heroic leadership of the principal alone, calling for distributing power and responsibility among individual school members and empowering people at different levels of the school to take the lead (Gumus *et al.*, 2018). Nevertheless, the concept of DL has been rather vague (Tian *et al.*, 2016). DL is considered a product of the synergetic interactions of school leaders, followers, and their situation to achieve common goals (Spillane, 2005; Leithwood *et al.*, 2008) and involves decision-making practices performed by multiple school staff members and stakeholders (OECD, 2014). When leadership is distributed, staff within the school have a chance to work together to develop knowledge collectively and collaboratively (Camburn *et al.*, 2003).

Empirical research has also evidenced the relationship between DL and teacher professional collaboration. Using structural equation modeling (SEM), Liu *et al.* (2021a) found statistically significant positive effects of DL on autonomy, collaboration and job satisfaction of teachers. The positive association of DL with self-efficacy and professional learning communities of teachers has also been confirmed (Bellibaş *et al.*, 2021). The recent study of Lin (2022) reported positive direct effects of DL on teacher innovativeness and professional collaboration. In view of the above, the following hypothesis is proposed.

H2. DL is significantly and positively related to teacher professional collaboration.

Relationship of TSE and collective teacher innovativeness with teacher professional collaboration. TSE. First defined by Bandura (1977) as an individual's belief in their capability to produce desired outcomes, self-efficacy in the field of education refers to teachers' belief in their abilities to achieve desired results in their teaching and students' learning (Bandura, 1995). TALIS divided TSE into three dimensions, namely self-efficacy in classroom management so that order in the classroom is maintained, self-efficacy in instruction using a variety of strategies and self-efficacy in student engagement, motivating and engaging students in active learning (OECD, 2019). Following Tschannen-Moron and Hoy (2001), the present study conceptualized TSE as teachers' judgment of their own ability to execute the behavior in the three dimensions mentioned above for the desired outcome of student engagement and learning.

When exploring factors related to TSE, Guo *et al.* (2011) found significant correlation between TSE and their sense of collaboration; while Marshall and Rendall (2020) observed positive association of TSE with more frequent professional collaboration. Voelkel and Chrispeels (2017) suggested TSE to be predictive of teachers working together; and Geijsel *et al.* (2009) found significant effects of TSE on their participation in professional learning activities. Taken together, these results indicate a strong link between TSE and teacher professional collaboration; and hence the following hypothesis is proposed.

H3. TSE is significantly and positively related to teacher professional collaboration.

Collective teacher innovativeness. In the field of education, innovation is one of the keys to successful school reforms (Kundu and Roy, 2016). In challenging and constantly changing educational contexts, teachers are expected to maintain and improve their personal innovativeness so as to improve the quality of education (Serdyukov, 2017). Collective innovativeness is of paramount importance in sustaining and spreading innovations in schools (Buske, 2018). Blömeke *et al.* (2021) considered collective teacher innovativeness a characteristic of an innovative school climate, which in turn fosters exchange and collaboration among teachers (OECD, 2014). In the study of Nguyen *et al.* (2021), teacher innovativeness was operationalized as teachers' perceptions of the extent to which teachers in their schools search for, develop and apply new ideas in their practices (OECD, 2019).

Empirical evidence has confirmed the relationship between collective innovativeness and professional collaboration among teachers (Ainley and Carstens, 2018). Blömeke *et al.* (2021) reported positive association of school innovativeness with enhanced teacher collaboration and that more innovative schools delivered better outcomes in terms of teacher collaboration and exchange. The case study conducted by Thomas *et al.* (2019) in Australia found that enabling a local curriculum innovation in literacy promoted teacher collaboration; and Goddard *et al.* (2007) observed enhancement in professional collaboration through teachers' collective innovation that requires teachers to discuss together and to share unique insights with each other. In view of the above, the following hypothesis is proposed.

H4. Collective teacher innovativeness is significantly and positively related to teacher professional collaboration.

Relationship of IL and DL with TSE. Besides a source and a contributor, IL has been found to be a predisposing factor (Fackler and Malmberg, 2016) and a positive predictor of TSE (Zheng *et al.*, 2018). Principals' IL behaviors such as developing a positive learning climate for teachers, observing teachers' instruction and giving feedback have been found to have direct and positive impact on TSE (Ma and Marion, 2021; Calik *et al.*, 2012). The study of Bellibaş and Liu (2017) evidenced a significant and positive relationship of principals' IL with TSE in classroom management, instruction and student engagement.

Through strengthening teachers' sense of responsibility in their instructional role and providing opportunities for teachers to participate in decision-making, DL contributes to TSE enhancement. Empirical investigations showed a direct relationship between DL and TSE, and the higher teachers think of DL, the higher the TSE self-efficacy reported (Sun and Xia, 2018). While prior research supports the positive effect of DL on TSE (Liu *et al.*, 2021b), their relationship is indirect with the significant effects mediated through trust in principal and job satisfaction (Zheng *et al.*, 2019). In view of the above, the following hypotheses are proposed.

H5. IL is significantly and positively related to TSE.

H6. DL is significantly and positively related to TSE.

Relationship of IL and DL with collective teacher innovativeness. Playing an important role in facilitating innovation of teachers and the school (Fullan, 2016b; Chesler *et al.*, 1963), principal IL is a determining factor behind successful implementation of change or innovation in schools (de Jong *et al.*, 2020). Although IL has positive influence on collective teacher innovativeness, the influence is indirect and mediated through shared practices among teachers and their sense of agency in learning effectiveness (Bellibaş *et al.*, 2020).

School innovation requires a creative organizational structure as well as decentralized leadership; hence, not only can DL foster innovation, it is a significant and positive predictor of teachers' use of innovative teaching practices (Spillane *et al.*, 2004; O'Shea, 2021). Brown *et al.* (2020) found that DL plays a key role in facilitating the mobilization of professional learning network-led innovations. While Lin (2022) reported a positive and direct impact of DL on teacher innovativeness and professional collaboration, Buyukgoze *et al.* (2022) found both direct and indirect effects on collective teacher innovativeness, as mediated by job satisfaction and professional collaboration. In view of the above, the following hypotheses are proposed.

H7. IL is significantly and positively related to collective teacher innovativeness.

H8. DL is significantly and positively related to collective teacher innovativeness.

Relationship of TSE with collective teacher innovativeness. Self-efficacy is a crucial component of innovative behavior in any field (Cropley and Cropley, 2009), the most influential factor on teachers' innovative behavior (Zainal and Matore, 2019) and a key motivational source that

can facilitate innovation (Cai and Tang, 2021). A recent study of Liu *et al.* (2022) confirmed TSE as an important booster of teacher creative self-efficacy and teacher innovation. Teachers with higher self-efficacy are more willing to try new methods to better serve students' needs (Allinder, 1994) and TSE can predict teachers' attitudes toward implementation of teaching for creativity (Huang *et al.*, 2019). In view of the above, the following hypothesis is proposed.

H9. TSE is significantly and positively related to collective teacher innovativeness.

Method
Data source
This research performed a secondary data analysis on the TALIS data obtained by the OECD in 2018 (OECD, 2018). TALIS data were collected using self-report questionnaires administered to school principals and teachers. A two-stage stratified sampling approach was adopted. The sample comprised the principals of 200 schools randomly selected in the first stage and 20 teachers arbitrarily chosen from each selected school in the second stage. TALIS was conducted in Taiwan from April to May 2018. All the selected 200 elementary school principals completed the survey, giving a response rate of 100%. The TALIS data therefore have a nested structure, with teachers nested within schools. Considering previous findings and the need for examining both principal and teacher perceptions (Urick and Bowers, 2017), this study considered teacher perceptions representing the teacher level and principal perceptions denoting the school level.

There were more male (65%) than female principal respondents (35%). The majority (84.7%) had bachelor's degrees, with some (8.7%) having doctoral degrees. Their average job tenure as a principal was 8 years. A total of 3494 elementary school teachers completed the survey. After eliminating responses with missing data, 3179 valid responses remained, making up a validity rate of 91.0%. There were more female (72.5%) than male teacher respondents (27.5%). Among them, 57.6% had bachelor's degrees and 41.9% had doctoral degrees. Their average job tenure as a teacher was 16.7 years.

Variables
IL
There are 11 items (TC3G22A-TC3G22 K) in the TALIS principal questionnaire asking how frequently principals engaged in different school leadership activities. Principals were asked to reply using a 4-point Likert scale. Of the 11 items, five have been utilized to measure IL in previous studies (Bellibaş *et al.*, 2020); they are "TC3G22 B: I observed instruction in the classroom," "TC3G22D: I took actions to support cooperation among teachers to develop new teaching practices," "TC3G22 E: I took actions to ensure that teachers take responsibility for improving their teaching skills," "TC3G22 F: I took actions to ensure that teachers feel responsible for their students' learning outcomes," and "TC3G22 G: I provided parents or guardians with information on the school and student performance." The confirmatory factor analysis (CFA) results showed good model fit (Goodness of fit index (GFI) = 0.982; Comparative fit index (CFI) = 0.988; Adjusted goodness of fit index (AGFI) = 0.947; Root mean square error of approximation (RMSEA) = 0.064) with an average variance extracted (AVE) of 0.48 and a composite reliability (CR) of 0.81.

DL
Three questions in the TALIS teacher questionnaire have been utilized to measure DL in previous studies (Bellibaş *et al.*, 2021). Teachers were asked to reply using a 4-point Likert scale. The three items are "TT3G48 A: This school provides staff with opportunities to

actively participate in school decisions," "TT3G48 B: This school provides parents or guardians with opportunities to actively participate in school decisions" and "TT3G48 C: This school provides students with opportunities to actively participate in school decisions." The CFA results showed good model fit (GFI = 0.999; CFI = 0.999; AGFI = 0.999; RMSEA = 0.001) with an AVE of 0.53 and a CR of 0.77.

TSE

Drawn upon past studies (Sun and Xia, 2018), three subscales in the TALIS 2018 teacher questionnaire were adopted to measure TSE, including efficacies for instructional practices, classroom management and student engagement. Each subscale contained four items. Teachers were asked to reply using a 4-point Likert scale. The four items for efficacy in instructional practices are "TT3G34 C: Craft good questions for students," "TT3G34 J: Use a variety of assessment strategies," "TT3G34 K: Provide an alternative explanation, for example when students are confused," and "TT3G34 L: Vary instructional strategies in my classroom." The items for efficacy in classroom management are "TT3G34D: Control disruptive behavior in the classroom," "TT3G34 F: Make my expectations about student behavior clear," "TT3G34H: Get students to follow classroom rules" and "TT3G34I: Calm a student who is disruptive or noisy." Those for efficacy in student engagement are "TT3G34 A: Get students to believe they can do well in schoolwork," "TT3G34 B: Help students value learning," "TT3G34 E: Motivate students who show low interest in schoolwork" and "TT3G34 G: Help students think critically." The CFA results showed good model fit (GFI = 0.968; CFI = 0.906; AGFI = 0.936; RMSEA = 0.042) with an AVE of 0.49 and a CR of 0.92.

Collective teacher innovativeness

Teacher innovativeness was measured using the scale of school team innovativeness in the TALIS 2018 teacher questionnaire (Nguyen *et al.*, 2021). Teachers were asked to reply using a 4-point Likert scale. The four items are "TT3G32 A: Most teachers in this school strive to develop new ideas for teaching and learning," "TT3G32 B: Most teachers in this school are open to change," "TT3G32 C: Most teachers in this school search for new ways to solve problems" and "TT3G32D: Most teacher in this school provide practical support to each other for the application of new ideas." The CFA results showed good model fit (GFI = 0.989; CFI = 0.975; AGFI = 0.895; RMSEA = 0.081) with an AVE of 0.73 and a CR of 0.91.

Teacher professional collaboration

A set of questions in the TALIS teacher questionnaire has been utilized to measure teacher professional collaboration in previous studies (Torres, 2019). Teachers were asked to reply using a 6-point Likert scale. The four items are "TT3G33 A: Teach jointly as a team in the same class," "TT3G33 B: Observe other teachers' classes and provide feedback," "TT3G33 C: Engage in joint activities across different classes and age groups (e.g., projects)" and "TT3G33H: Take part in collaborative professional learning." The CFA results showed good model fit (GFI = 0.992; CFI = 0.952; AGFI = 0.958; RMSEA = 0.069) with an AVE of 0.44 and a CR of 0.75.

As mentioned in Fornell and Larcker (1981), if the AVE is less than 0.5, but the CR is higher than 0.6, the convergent validity of the construct can be adequate. In view of this, the items constituting the scales provided a valid representation of the latent constructs of the study.

Control variables

Variables that may affect teachers' professional collaboration, including the characteristics of principals and teachers, were included in the model. The control variables for principals

included gender, educational qualification, years of experience, school location, private and public schools, and socioeconomic status (SES), while the control variables for teachers included gender, educational qualification and years of experience.

Analytical strategy

The mean scores of variables are estimated for the analysis. For an individual response, the score of a specific latent variable is the mean score of items developed to measure the variable. The mean score of that latent variable can then be obtained by dividing the sum of scores for that variable by the total number of valid samples. The computation rule was applied to the mean scores of TSE, collective teacher innovativeness and teacher professional collaboration at the teacher level and IL at the school level. With regard to DL at the school level, DL scores of teachers belonging to the same school were first averaged and taken as school level DL, then the mean score of school level DL was estimated by dividing the sum of scores from all schools by the total number of schools.

The analysis involved the following stages. First, the construct validity of the measurement was examined using CFA. Then, the appropriateness of multilevel analysis was tested. For TSE, collective teacher innovativeness and teacher professional collaboration, the intraclass correlation (ICC) was calculated to detect whether there were significant variations at the school level. An ICC exceeding 0.05 was used as the criterion to determine whether multilevel analysis was warranted (Geldhof *et al.*, 2014).

For testing the hypotheses, multilevel regression analysis was conducted to examine the relationships between IL and collective teacher innovativeness, between IL and TSE, between DL and collective teacher innovativeness, between DL and TSE, between TSE and collective teacher innovativeness, between TSE and teacher professional collaboration, between collective teacher innovativeness and teacher professional collaboration, between IL and teacher professional collaboration, as well as between DL and teacher professional collaboration.

The multilevel analysis was accomplished using hierarchical linear modeling (HLM) 7 (Raudenbush *et al.*, 2017). HLM is considered appropriate for analyzing data from teachers nested in schools (Ma and Marion, 2021) and has the advantage of identifying the relationships between predictor and outcome variables by taking both school level and teacher level regression relationships into account (Hoffmann, 1997).

Results

Relationships between variables

Table 1 lists the means, standard deviations (SD) and correlations among the variables. As can be seen, TSE was significantly and positively related to collective teacher innovativeness ($r = 0.17$, $p < 0.001$); TSE was significantly and positively related to teacher professional collaboration ($r = 0.17$, $p < 0.001$); collective teacher innovativeness was significantly and positively related to teacher professional collaboration ($r = 0.27$, $p < 0.001$); and the correlation between IL and DL did not reach significant levels ($r = -0.06$, $p = 0.413$).

Null model

The null models served to confirm whether the outcome variables of interest differ between schools. Table 2 shows the null models with TSE, collective teacher innovativeness and teacher professional collaboration as the outcome variables. As can be seen, the total variance in collective teacher innovativeness was 3.3% between schools and 28.2% within schools (ICC = 10.4%), while that in teacher professional collaboration was 15.3% between schools and 83.6% within schools (ICC = 15.5%). These between-school variances were significant,

indicating that teacher perceptions of collective teacher innovativeness and teacher professional collaboration vary significantly across schools, thus justifying the subsequent multilevel analyses (Geldhof *et al.*, 2014).

Hypothesis testing
This study performed Bonferroni correction to account for multiple comparisons with an adjusted significance level. That is, the Bonferroni-corrected p value is calculated as the original critical p value divided by the number of hypotheses performed. The Bonferroni-corrected p value is estimated as 0.006 (= 0.05/9) with pre-determined significant p value being 0.05 and number of hypotheses being 9. Table 3 shows the HLM results of hypothesis testing and Figure 2 shows the study model with parameter estimates.

As shown in Table 3, the relationship marked in gray was insignificant with Bonferroni corrections, yet it is significant before the adjustment. All in all, the impact of IL on TSE was insignificant and so was the impact of DL on TSE, rendering both H5 and H6 unsupported. Results in Model 2 show that the impact of IL on collective teacher innovativeness was insignificant, rendering H7 unsupported; while DL is positively and significantly related to collective teacher innovativeness ($\beta = 0.41$, $p < 0.006$), thus supporting H8. There is a significant positive relationship between TSE and teacher collective innovativeness ($\beta = 0.20$, $p < 0.006$), providing evidence in support of H9. Results in Model 3 shows that IL is positively and significantly related to teacher professional collaboration ($\beta = 0.19$, $p < 0.006$), thus supporting H1. DL is also positively and significantly related to teacher professional collaboration ($\beta = 0.41$, $p < 0.006$), thus supporting H2. TSE is positively and significantly related to teacher professional collaboration ($\beta = 0.26$, $p < 0.006$), thus

Variable	M	SD	1	2	3	4	5
Teacher level							
1. TSE	3.19	0.46	(0.92)				
2. Collective teacher innovativeness	2.92	0.56	0.17**	(0.91)			
3. Teacher professional collaboration	2.77	0.99	0.17**	0.27**	(0.73)		
School level							
4. IL	2.82	0.52	0.05**	0.05**	0.12**	(0.79)	
5. DL	2.69	0.20	0.00	0.13**	0.10**	−0.03	(0.77)

Note(s): Cronbach's α are given in parentheses
** $p < 0.01$
Source(s): Table created by authors

Table 1.
Means (M), standard deviations (SD) and correlations among variables

	TSE	Collective teacher innovativeness	Teacher professional collaboration
Fixed effect			
Intercept(γ_{00})	3.19***	2.93***	2.80***
Random effect			
Teacher level(σ^2)	20.9%***	28.2%***	83.6%***
School level(τ_{00})	0.3%	3.3%***	15.3%***
ICC	1.3%	10.4%	15.5%

Note(s): ICC = $\tau_{00}/(\tau_{00}+\sigma^2)$
*** $p < 0.001$
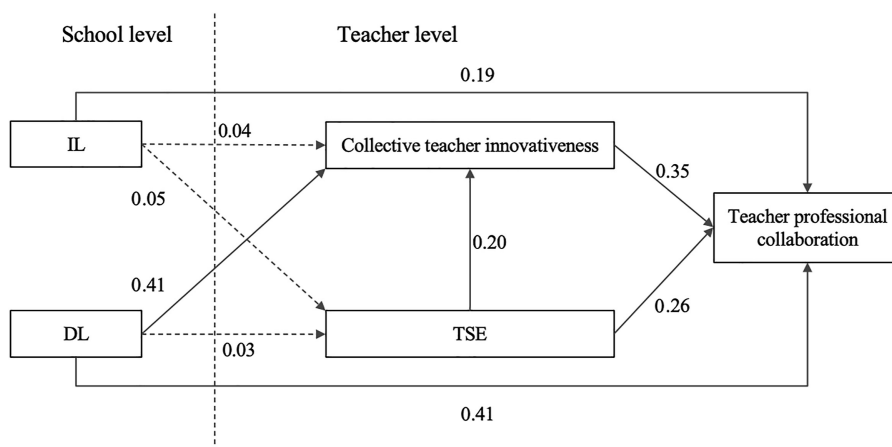**Source(s):** Table created by authors

Table 2.
Results of null model

Independent variable	TSE Model 1	Dependent variable Collective teacher innovativeness Model 2	Teacher professional collaboration Model 3
Intercept	3.06 (0.000)[*]	0.96 (0.007)	−1.33 (0.034)
School level (N = 200)			
IL	0.05 (0.021)	0.04 (0.226)	0.19 (0.000)[*]
DL	0.03 (0.625)	0.41 (0.000)[*]	0.41 (0.000)[*]
Teacher level (N = 3179)			
TSE		0.20 (0.000)[*]	0.26 (0.000)[*]
Collective teacher innovativeness			0.35 (0.000)[*]
Random effect			
School level	0.003 (0.080)	0.026 (0.000)[*]	0.086 (0.000)[*]
Teacher level	0.205 (0.000)[*]	0.269 (0.000)[*]	0.785 (0.000)[*]

Note(s): p value is given in parentheses
[*]$p < 0.006$
Source(s): Table created by authors

Table 3.
Results of HLM

Source(s): Figure created by authors

Figure 2.
Study model diagram
with parameter
estimates

supporting H3. Collective teacher innovativeness is positively and significantly related to teacher professional collaboration ($\beta = 0.35$, $p < 0.006$), thus supporting H4. Table 4 summarizes the results of hypothesis testing.

Discussion and conclusions
The current research has moved one step forward and provided more holistic and nuanced evidence for the associations among IL, DL, TSE, teacher collective innovativeness and teacher professional collaboration. Of note, this study highlights the significant impact of principal leadership as both principals and teachers work in the same environment and culture co-shaped through their interaction and collaboration.

Hypothesis	Results
H1 IL is significantly and positively related to teacher professional collaboration	Supported
H2 DL is significantly and positively related to teacher professional collaboration	Supported
H3 TSE is significantly and positively related to teacher professional collaboration	Supported
H4 Collective teacher innovativeness is significantly and positively related to teacher professional collaboration	Supported
H5 IL is significantly and positively related to TSE	Unsupported
H6 DL is significantly and positively related to TSE	Unsupported
H7 IL is significantly and positively related to collective teacher innovativeness	Unsupported
H8 DL is significantly and positively related to collective teacher innovativeness	Supported
H9 TSE is significantly and positively related to collective teacher innovativeness	Supported

Source(s): Table created by authors

The present findings revealed that IL and DL influence teacher professional collaboration through different paths. On the one hand, DL promotes teacher professional collaboration through direct influence on teacher collective innovativeness. On the other hand, IL directly promotes teacher professional collaboration without the mediation of TSE and collective teacher innovativeness. These results supported the direct effect of both IL and DL on teacher professional collaboration with DL having a larger impact than IL.

To begin with, IL, DL, TSE and teacher collective innovativeness all have direct impacts on teacher professional collaboration (H1, H2, H3 and H4, respectively). Consistent with the results of Webs and Holtappels (2018) and Nguyen et al. (2021), the direct effect of IL and DL on teacher professional collaboration illustrates the vital role of principal leadership in promoting collaboration among teachers. Meanwhile, the positive relationship of TSE with teacher professional collaboration observed in this study echoes the findings of Marshall and Rendall (2020). Finally, the significant and positive relationship of teacher collective innovativeness with teacher professional collaboration observed in this study is in line with the results of Blömeke et al. (2021).

Principals, as instructional leaders, can promote TSE by observing class instruction and providing feedback and by developing a positive learning climate for teachers (Ma and Marion, 2021; Calik et al., 2012). Obtained through conservative Bonferroni correction, the present findings evidenced the insignificant relationship of IL with TSE, rendering IL as a predictor of TSE (H5) unsupported. This result was inconsistent with findings of Calik et al. (2012) and Zheng et al. (2018). Moreover, contrary to the findings of Liu et al. (2021b), the present results obtained in Taiwan's educational context do not show positive effect of DL on TSE (H6) but echo the absence of direct effect of DL on TSE reported by Zheng et al. (2019). The discrepancy may be attributed to the fact that enhancement in self-efficacy requires other contributors such as job satisfaction and trust in the principal (Zheng et al., 2019), not just opportunities for active participation in school decision-making.

The absence of direct effect of IL on teacher collective innovativeness observed in this study (H7) is inconsistent with the findings of de Jong et al. (2020). A possible reason for such difference is the lack of opportunity for collective innovation with IL principals setting vision and goals against which teachers' performance will be evaluated (Bridges, 1967). Nevertheless, our findings agree with those of Bellibaş et al. (2020) in that IL cannot directly influence instructional practice but indirectly through promoting interaction among teachers and their participation in professional learning. In line with O'Shea (2021), this study confirmed the direct and positive impact of DL on teacher collective innovativeness (H8). Same as Huang et al. (2019), the present results support TSE as an effective predictor of teacher collective innovativeness (H9); hence, increasing TSE will boost innovations among teachers.

This study has explained theoretically the unsupported hypotheses, namely H5, H6 and H7. In addition to theoretical explanations, the unconfirmed hypotheses might be considered methodological in nature; that is, limitations of the data as opposed to the non-existence of the relationships that this study tries to measure.

Implications
Opportunities should be provided for teachers to share feedback on collective innovative practices and participate in professional development activities with the ultimate goal of improving student learning. Under IL, principals giving feedback and suggestions on classroom teaching and facilitating knowledge and experience sharing can motivate teachers for professional collaboration. Hence, for more effective IL, it is recommended that principals should participate more in the school community, solve school problems through exchange and collaboration with teachers and promote professional learning and sharing among teachers. All these will facilitate changes and innovations in classroom teaching. For teachers, they should acquire the necessary skills, especially in the development of new pedagogical practices and the integration of diverse forms of pedagogical content and technology, which in turn may improve teacher innovativeness.

Regarding DL, the principal through power delegation and empowerment creates a positive and democratic school atmosphere and offers teachers the opportunity to participate in school decision-making. When leadership is distributed, it enables teachers to utilize their knowledge, passion and imagination, which is vital to the success of educational improvements (Fullan, 2016a; Buske, 2018). As a result, teachers are engaged in decisions on which innovations to embrace and how to implement them, paving the way to teacher professional collaboration. In addition, principals should also promote work autonomy and assist teachers in their creative work. To encourage collaborative innovation, principals should reduce interpersonal distance between them and the staff (de Jong *et al.*, 2020). Under constant evolution, collective innovativeness is more powerful than individual innovativeness. Moreover, for the sustainable development of society, an innovative school atmosphere is needed and innovative teacher education can promote the realization of this goal through principal leadership and the organization of resources. Hargraves and O'Connor (2018) have detailed the suggestions on daily practice for principals in terms of professional collaboration with teachers.

A limitation of this study is that the concepts of the studied variables have their bases on those conceptualized in OECD (2014) and OECD (2019) and we were obliged to operationalize them as they were conceptualized in the TALIS dataset. Although the OECD draws on available literature when developing a construct, the constructs used in the TALIS dataset may not capture every component of a given phenomenon. The limitations have been discussed in depth by Bellibaş *et al.* (2021) and Kılınç *et al.* (2022). For example, the construct of DL involves only the participation of teachers, students and parents in the school decision-making process. The concept that DL reflects the interactions of school leaders, followers and their situation to achieve common goals (Spillane, 2005; Leithwood *et al.*, 2008) is dismissed. TALIS is designed as a sequence of cross-sectional surveys. Possible analytical limitation exists for the use of correlation data for examining causal relationships. In future, longitudinal, experimental or quasi-experimental studies need to be conducted (Hallinger, 2011).

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