Collective teacher innovativeness in 48 countries: Effects of teacher autonomy, collaborative culture, and professional learning

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Highlights

- Teacher autonomy and school culture influence collective teacher innovativeness.
- Teacher autonomy and collaboration are positively interrelated.
- A collaborative culture promotes teachers' participation in professional learning.
- Collective participation in professional learning enhances innovativeness.

Abstract

The current article examines the effects of teacher classroom autonomy and school culture on collective teacher innovativeness, through integrated professional learning. This examination draws upon an analysis of TALIS dataset 2018 gathered from 241 426 teachers of 15 672 schools in 48 OECD countries, using a multilevel structural equation modelling approach. The article underscores the importance of enhancing teachers' sense of classroom autonomy and collaborative school culture to promote collective teacher innovativeness. It suggests that a collaborative culture would encourage teachers to participate in integrated professional learning activities, and that collective participation in professional learning would enhance teachers' collective innovativeness.

Keywords: *collaborative culture; innovativeness; multilevel structural equation modelling; professional learning; teacher autonomy; teaching and learning international survey (TALIS)*.

1. Introduction

Innovation in education is critical in promoting positive changes for improvement and sustainable development in schools and beyond (Serdyukov, 2017). Teachers' innovative behaviours are central to implementation of innovations in schools (McGeown, 1980; Thurlings, Evers, & Vermeulen, 2015). Innovative behaviour is defined as a self-initiated process of generating, promoting and realising change (Thurlings, Evers, & Vermeulen, 2015). Teacher innovativeness, which is conceptualised as teacher receptivity, openness, and willingness to adopt change (Fullan, 2007; Goldsmith, 1986), functions as a critical factor influencing teacher innovative behaviours and a prerequisite to innovation and change (Kern & Graber, 2018). Research has explored

innovativeness at the individual teacher level and implementation of specific innovations and reforms (e.g., Akar, 2019). This line of literature has evidenced and conceptualised important issues around teacher change. However, it is argued that the field would benefit from more studies that centrally discuss collective innovativeness in schools (Buske, 2018; Moolenaar et al., 2014; *see also* the review of Newman, Round, Wang, & Mount, 2020). This *first argument* for the current article is highly credible since collective innovativeness is of paramount importance in implementation, sustainment, and spreading of innovations in schools (Buske, 2018; Schwabsky, Erdogan, & Tschannen-Moran, 2019; Moonlenaar et al., 2014).

A limited albeit growing number of empirical studies have identified important factors potentially influencing teacher innovativeness and innovative behaviours, including teacher autonomy defined as teachers' degree of given professional discretion (Buske, 2018) and school culture (Gilad-Hai & Somech, 2016). These studies have been conducted in a few single-nation contexts such as Germany (Buske, 2018) and Israeli (Gilad-Hai & Somech, 2016). To further advance the current literature, *secondly* it is *argued* to require sophisticated analyses of robust datasets collected across a number of countries. Such analyses would forward a holistic understanding of the conditions for collective teacher innovativeness.

Teachers' behaviours and attitudes towards innovative changes for improving professional practices develop along the process of their participation in professional learning, as discussed further in the subsequent sections. Professional learning may occur in formal learning activities (e.g., attending a university-based professional development course) and job-embedded professional learning activities in the workplace (e.g., in-depth professional conversations). A synthesis of literature suggests that teacher autonomy (Kwakman, 2003) and school culture (Jurasaite-Harbison & Rex, 2010; Opfer & Pedder, 2011) influence teacher's participation in professional learning activities, and that teacher professional learning is likely to promote teacher innovativeness (Clarkea & Hollingsworth, 2002; Guskey, 2002; Timperley, Wilson, Barrar, &

Fung, 2007). The findings and implications from these separated studies highlight professional learning as a potential mediator in the relationships between teacher autonomy and school culture and teacher innovativeness. While a great deal of research has focused exclusively on either formal or job-embedded professional learning (e.g., Nguyen & Ng, 2020; Jurasaite-Harbison & Rex, 2010), researching integrated professional learning within a single study is *argued* to provide added value to the evidence base (Darling-Hammond, Hyler, & Gardner, 2017; Garet et al., 2001; Parise & Spillane, 2010; Shirrel, Hopkins, & Spillane, 2019). Integrated professional learning in this article involves a combined form of formal and job-embedded professional learning of teachers.

Built on the three aforementioned arguments, this article examines the effects of teacher classroom autonomy and collaborative school culture on collective teacher innovativeness and looks at the potential role of integrated professional learning in mediating these effects. This examination was based on an analysis of the database of the OECD Teaching and Learning International Survey 2018 (TALIS 2018) gathered in 48 countries. Three underlying research questions which guided this analysis are presented as follows.

(1) What are the relationships among teacher autonomy, collaborative culture, and collective teacher innovativeness?

(2) How does integrated professional learning mediate the relationships between teacher autonomy and collaborative school culture and collective teacher innovativeness?

(3) How much variance of findings from Research Questions 1 and 2 above is explained at the teacher and school level?

The article advances an understanding, of the international scope, on factors influencing collective teacher innovativeness and the mediational role of integrated professional learning in schools. This understanding would provide evidence-based insights into promoting collective teacher innovativeness that encourages change for improvement in schools.

2. Literature review

The current section presents the literature relevant to collective teacher innovativeness, teacher autonomy, collaborative school culture and teacher professional learning. This consideration of relevant literature informs development of the conceptual framework for this study.

2.1. Collective teacher innovativeness

Innovation has been viewed as a new thing such as a product, an idea, a method and the process of introducing and implementing that new thing (Gopalakrishnan & Damanpour, 1997). This process involves three stages: ideation, implementation, and a change as a result of implementing that innovation (Serdyukov, 2017). In school settings, an innovation may be a new method or strategy in pedagogy or assessment that aims to enhance teaching and learning quality. Innovation is a crucial factor that contributes to enhanced teaching quality and student learning and school improvements (Cohen-Vogel et al., 2016; Serdyukov, 2017; Zimmer et al., 2017).

Innovativeness in schools is conceptualised as teachers' receptivity, adoption, and internalisation of innovative changes and their continual participation in change-related professional activities (McGeown, 1980). Innovativeness can be defined and measured at the individual level (Agarwal & Prasad, 1998; Akar, 2019) and collective level (e.g., team or organisation) (Buske, 2018; Moonlenaar et al., 2014; Schwabsky, Erdogan, & Tschannen-Moran, 2019). Innovativeness at the individual level refers to an individual teacher's openness to new ideas while collective innovativeness can be understood as a team's or an organisation's receptivity and readiness for change (Buske, 2018). The current article centres on collective innovativeness of teachers in schools.

Teacher innovativeness is subject to a compound of individual and organisational factors. Firstly, the theoretical models of teacher change (Clarke & Hollingworth, 2002; Guskey, 1986; Timperley, Wilson, Barrar, & Fung, 2007) suggest that teachers' innovativeness might result from

the process of their professional learning and experimentation of new practices. Clarke and Hollingsworth (2002) highlight that teachers' change, of varying degrees, inevitably occurs through their participation in professional learning activities. Secondly and theoretically, there are some arguments for the benefits of supporting teacher autonomy in enhancing innovativeness and proximal factors such as professional motivation and satisfaction (e.g., Cribb & Genwirtz, 2007; Deci & Ryan, 2008). Thirdly and empirically, the factors pertaining to school climate and culture such as an emphasis on academic excellence (Schwabsky, Erdogan, & Tschannen-Moran, 2019), openness and support for change (McGeown, 1980; Moolenaar et al., 2014), and social support among teachers and school leaders (Gilad-Hai & Somech, 2016) have been evidenced as enablers of teacher innovativeness.

In summary, the literature has identified teacher autonomy, collaborative school culture and teacher professional learning as potential factors influencing teacher innovativeness. The subsequent parts elaborate on these major factors.

2.2. Teacher autonomy

Professional autonomy is a complex concept that refers to multiple levels: individual autonomy, collective autonomy, and institutional autonomy (Cribb & Gewirtz, 2007). At the individual level, autonomy conceptually concerns two aspects of degree of discretion (Dikilitas & Mumford, 2019; Evan & Fischer, 1992; Lam & Reinders, 2008) and self-governance and capacity to exercise that professional discretion (Benson, 2010; Cribb & Gewirtz, 2007). From the first perspective, Evans and Fischer (1992) define autonomy as "the amount of freedom a worker has to schedule their work and to determine the procedures to be used in carrying it out" (p. 1171). This view of centrally linking autonomy to the freedom of choice to exercise professional practices has been widely recognised in the literature (e.g., Dikilitas & Mumford, 2019; Lam & Reinders, 2008). It implies that individuals have a high degree of control over specific domains of professional tasks, processes, and outcomes that is exercised based on their moral and ethical judgements (Evans &

Fischer, 1992). An evolving perspective views individual autonomy as both freedom and internal capacity to make decisions and to act independently (Benson, 2010; Cribb & Gewirtz, 2007; Mausethagen & Mostad, 2015; Worth & Van den Brande, 2020).

In terms of dimensionality, Breaugh (1985) delineates autonomy into three dimensions related to work method, scheduling, and evaluation of outcomes. Breaugh's (1985) first two dimensions pertain to professionals' freedom towards their work method and processes, while the third dimension refers to their capacity to decide on evaluation criteria of work performance. Specifically considering teacher classroom autonomy, Vangrieken, Grosemans, Dochy, and Kyndt (2017) distinguish two aspects: didactical-pedagogical autonomy (e.g., in preparing lessons, teaching methods, student assignment, and managing student behaviour) and curricular autonomy (e.g., decisions about curriculum, setting goals for students). Teacher autonomy in the current article refers to the degree of teachers' discretion or freedom in making decisions on their course content, selection of teaching methods, assessment of student learning, student discipline issues, and the amount of homework for their students, as defined by OECD (2019; 2020).

There are theoretical perspectives or normative arguments for the positive effects of individual autonomy (e.g., Deci & Ryan, 2008; Little, 1995). The self-determination theory of Deci and Ryan (2008) outlines the prominent factors influencing two types of employees' motivation. The factor of autonomy (i.e., discretion in professional decision-making and actions) positively influences an employee's intrinsic motivation, which in turn influences job satisfaction, retention and performance (Deci & Ryan, 2008). Little (1995) argues that teachers with a high sense of professional autonomy tend to be active and innovative in promoting student autonomy. Cribb and Genwirtz (2007) highlight teacher autonomy as a source of job satisfaction, well-being, experimentation and innovation, and effectiveness. Granting teachers professional autonomy would promote "creativity and innovation" in the countries that have "a well-prepared and independent teaching workforce" (OECD 2020, p. 32).

Some of these positive perspectives on teacher autonomy have been empirically verified in a few contexts (e.g., Skaalvik & Skaalvik, 2014; Worth & Van den Brande, 2020). Teachers' perceptions of professional autonomy are positively linked with their job satisfaction (Dou, Devos, & Valcke, 2017; Skaalvik & Skaalvik, 2014; Worth & Van den Brande, 2020) and their professional commitment and engagement (Skaalvik & Skaalvik, 2014). Buske (2018), based on an analysis of survey data from 896 teachers of 15 vocational schools in Germany, stated that principal support and teacher autonomy in making decisions on classroom practices positively influence teachers' innovativeness.

The literature has outlined a variety of factors influencing teachers' perceptions of their professional autonomy such as policy context (Benson, 2000; Lundström, 2015), school structure (Benson, 2010), and teacher attitudes (Pearson & Hall, 1993). Research has also suggested ways to promote teachers' effective enactment of their autonomy, within prevailing constraints, such as strengthening development of teachers' informed professional decision-making in teacher education programmes (e.g., Manzano Vázquez, 2018) and supporting teacher research (e.g., Dikilitaş & Mumford, 2019; Wang & Zhang, 2014).

2.3. Collaborative school culture

In the literature, there are two overlapping terminologies pertaining to teaching and learning environments: school culture and school climate. School culture has its origins in anthropology while school climate is derived from the discipline of psychology (Aldridge & Fraser, 2016). Van Houtte (2005) views school culture as a factor of school climate while Schoen and Teddlie (2008) conceptualise school climate as a level of school culture.

Research has classified domains or dimensions to measure each construct. For example, Johnson, Stevens, and Zvoch (2007) propose four dimensions of school climate: collaboration, interpersonal relationships of staff and students, decision-making, and instructional innovation. Wang and Degol (2016) characterise school climate as a multidimensional construct that

incorporates four dimensions, namely safety, community, academic, and institutional environment. The dimension of community includes factors of interpersonal relationships of staff and students and opportunities for participative decision-making in schools. Schoen and Teddlie (2008) incorporate four dimensions to measure this construct: professional orientation, organisational structure, quality of the learning environment, and student-centred focus. The dimension of professional orientation involves a degree of teachers' collaborative professionalism centred on student learning. The dimension of organisational structure includes factors of leadership styles (e.g., shared leadership), communication, and processes (e.g., decision-making).

These typologies suggest school climate and school culture are multifaceted constructs and inextricably interrelated. These two constructs clearly share some mutual dimensions regarding social systems (e.g., interpersonal relationships and interactions in a school), teacher collaboration, and school processes (e.g., decision-making). The current article adopts the term of collaborative culture (Carpenter, 2015; Lieberman, 1990) to refer to a school culture of shared decision-making and responsibility, teacher collaboration, and social support in schools.

Research has argued for some effects of collaborative culture on professional learning and school innovation in schools (e.g., Geijsel, Sleegers, Stoel, & Krüger, 2009; Goddard, Goddard, & Tschannen-Moran, 2007; Somech, 2010). Geijsel, Sleegers, Stoel, and Krüger (2009) suggest that participative decision-making (as a characteristic of collaborative culture) has a positive, indirect effect on teacher professional learning activities through enhancing teacher self-efficacy and internalising school goals into teacher personal goals. Goddard, Goddard, and Tschannen-Moran (2007) suggest that teacher collaboration in a positive culture might foster professional learning for improved classroom instruction. Nguyen and Ng (2020) assert that teacher collaboration is a crucial form or setting for ongoing professional learning and that sustained professional learning requires leadership advocacy and a supportive school culture with positive teacher interrelationships.

At the organisational level, Somech (2010) proposes an analytical framework suggesting the impacts of teacher participation in school-level decision making on school productivity and innovation. Somech's (2010) analytical framework was constructed from a review of comprehensive literature, yet, of inconclusive or inconsistent findings, and therefore remains open for empirical verification across contexts.

2.4. Teacher professional learning

Teacher professional learning is a critical contributor to enhancing teaching quality, securing student learning, and promoting educational reforms and improvements (Bakkenes, Vermunt, & Wubbels, 2010; Darling-Hammond, Hyler, & Gardner, 2017; Lieberman & Pointer Mace, 2008; Parise & Spillane, 2010). Teacher learning is an individual and social process that occurs through ongoing participation and practice (Avalos, 2011; Lieberman & Pointer Mace, 2008).

Teacher professional learning includes activities of formal learning such as attending professional development workshops and courses (Garet et al., 2001) and those of job-embedded learning such as peer observation and mentoring (Parise & Spillane, 2010). The formal, traditional model provides teachers with relatively structured professional development (e.g., courses and programmes) delivered by university teachers and researchers outside their schools. This model of traditional teacher learning is grounded on the ideology of supporting teachers with "knowledge for practice" (Cochran-Smith & Lytle, 1999) from the formal knowledge base (i.e., knowledge generated from research). Teachers are expected to acquire this formal knowledge and implement it in their schools (Vescio, Ross, & Adams, 2008).

Job-embedded professional learning tends to be conceptualised as "a socially constructed process of learning and development that is largely embedded in activities that occur inside of schools" (Hallinger & Kulophas 2019, p. 4). This type of professional learning aligns with the theoretical perspectives of situated learning (Camndy, 1991; Darling-Hammond, 1998; McLaughlin, 1997; Putnam & Borko, 2000). These perspectives imply that job-embedded teacher

learning occurs as a result of teachers' participation in professional activities and interactions in their schools and occasionally beyond (Kwakman, 2003). Research has suggested that both formal and job-embedded professional learning impacts teachers' instructional practices (e.g. Buckler, Cordingley, & Timperley, 2009; Cordingley, 2015; Garet et al. 2001; Parise & Spillane, 2010; Shirrel, Hopkins, & Spillane, 2019).

The literature has documented noteworthy features of effective teacher professional learning (Garet et al., 2011; Hiebert, 1999; King & Newmann, 2001; Lieberman & Pointer Mace, 2008). These include explicit focus on content knowledge, curriculum, and classroom instruction (Garet et al., 2011; King & Newmann, 2001); ongoing collaboration within and between schools (Darling-Hammond, Hyler, & Gardner, 2017; Lieberman & Pointer Mace, 2008); sustained opportunities for active learning (Darling-Hammond, Hyler, & Gardner, 2017; Garet et al., 2011; King & Newmann, 2001); access to the expertise of external researchers and coaches (King & Newmann, 2001); coherence between learning activities (Garet et al., 2011); and appropriate duration of learning (Darling-Hammond, Hyler, & Gardner, 2017; Garet et al., 2011). These features underscore the importance of ongoing, sustained, collaborative learning activities and value of learning from teacher peers as well as from external coaches and scholars through professional development events (e.g., courses).

Opportunities for teacher professional learning need to be deliberately orchestrated, nurtured and sustained. Teacher professional learning is susceptible to a multiplicity of factors at the system, organisational, and individual levels. Formal continuing professional development is contractually specified in many national systems such as Russia and Singapore (*see* Harris et al., 2014). In these systems, teachers are normally supported financially to participate in formal continuing professional development events such as courses and workshops. Some systems also aim to systematically promote job-embedded professional learning through establishing formal professional learning communities in all schools (*see* Nguyen & Ng, 2020).

At the organisational level, research has evidenced the effects of school culture, structure, and leadership on teacher professional learning (Bektaş, Kılınç, & Gümüş, 2020; Gümüş, 2013; Jurasaite-Harbison & Rex, 2010; Kwakman, 2003; Leithwood, Leonard, & Sharratt, 1998; Opfer & Pedder, 2011; Parise & Spillane, 2010). For example, Leithwood, Leonard, & Sharratt (1998) accentuate a collaborative organisational culture characterised by mutual teacher support and receptivity of teacher-led innovations as a positive factor influencing teacher professional learning. Jurasaite-Harbison and Rex (2010) identify key characteristics of a school conducive to teacher job-embedded professional learning that has a positive culture promoting professional interactions and collaboration between and among teachers and school leaders.

Leadership at different levels has been evidenced to influence professional learning. The roles of principal leadership (e.g., Nguyen, Ng, Luo, & Mansor, 2020; Printy, 2008; Robinson, Lloyd, & Rowe, 2008), middle leadership (e.g., Bryant, Wong, & Adames, 2020; Harris, Michelle, Nashwa, & Nguyen, 2019), and teacher leadership (e.g., Nguyen, Harris, & Ng, 2019; Nguyen & Ng, 2020; Stoll et al., 2006) in promoting teacher professional learning in schools have been documented in the extant literature.

At the individual level, the intensity and quality of professional learning is dependent on the factors such as perceived teacher job satisfaction and autonomy, teacher efficacy, professional commitments, prior experiences and knowledge, and beliefs of teaching and learning (Kwakman, 2003; Liu & Hallinger, 2018; Opfer & Pedder, 2011).

3. Conceptual framework

The literature discussed above informs development of the conceptual framework or model for the current study. Figure 1 proposes relationships among the variables of focus in the article, namely teacher autonomy, collaborative culture, integrated teacher professional learning, and teacher team innovativeness. This model examines the relationships among these variables at both the individual teacher and school levels.

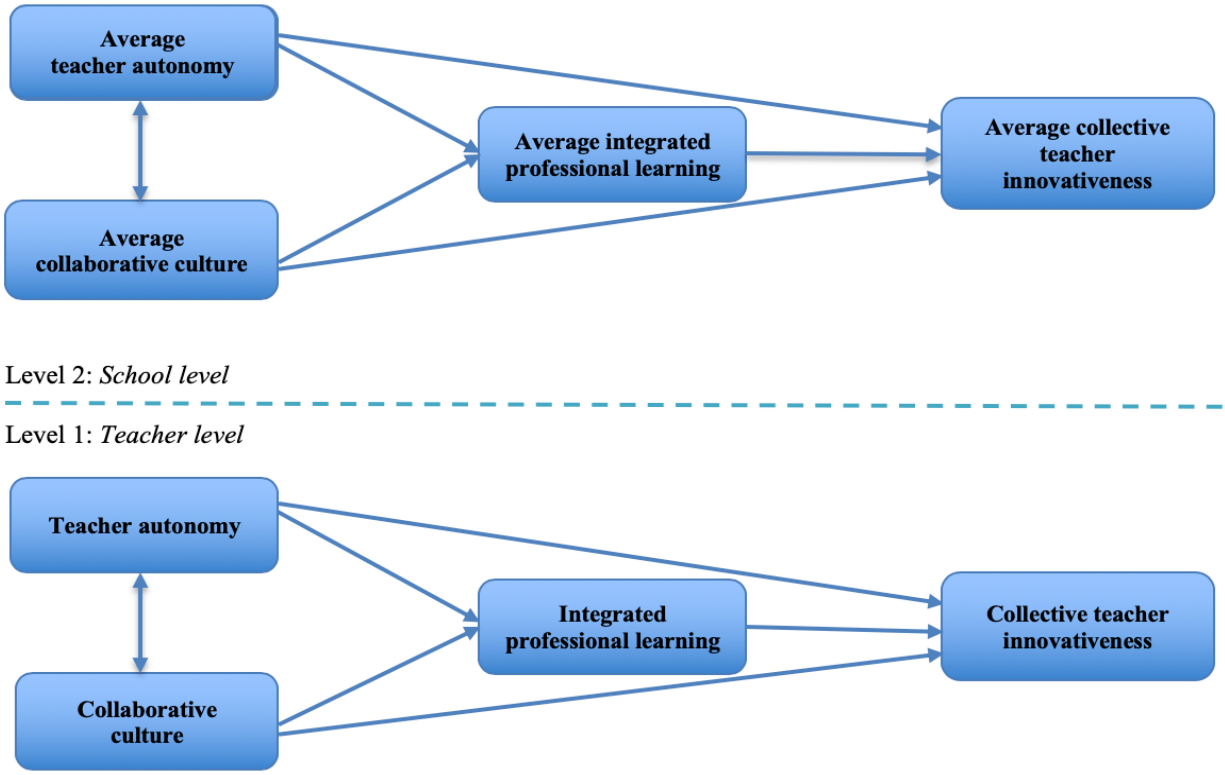

Figure 1. Conceptual model of relationships between teacher autonomy, collaborative culture, integrated professional learning, and collective teacher innovativeness.

The constructs of teacher autonomy and collaborative culture are proposed as two independent variables in this model. This proposal is based on the extant literature regarding the possible effects of teacher autonomy and school culture on teacher learning and teacher innovativeness and change (Cribb & Genwirtz, 2007; Geijsel, Sleegers, Stoel, & Krüger, 2009; Goddard, Goddard, & Tschannen-Moran, 2007; Somech, 2010). The current article speculates that teacher autonomy and collaborative culture are not mutually exclusive; these two variables are correlated. This speculation is grounded upon the conceptual framework of Vangrieken, Grosemans, Dochy, and Kyndt (2017) that suggests interrelationships between teacher autonomy and collaborative school culture. In addition, one aspect of collaborative culture conceptualised in this article refers to participative school decision-making that was found to be positively related to teachers' feeling of autonomy (*see* Lu, Jiang, Yu, & Li, 2015).

This article takes an integrated approach to conceptualise teacher professional learning (Garet et al., 2001; Parise & Spillane, 2010; Shirrel, Hopkins, & Spillane, 2019). More

specifically, integrated professional learning refers to teacher participation in both formal learning opportunities such as courses and workshops outside their schools and job-embedded workplace learning through, for example, peer observation and peer coaching. Integrated professional learning is posited as a mediating variable for three reasons. Firstly, there are a number of studies (e.g., Jurasaite-Harbison & Rex, 2010; Kwakman, 2003; Leithwood, Leonard, & Sharratt, 1998; Opfer & Pedder, 2011) that accentuate school culture and climate as a major factor influencing teacher professional learning, as discussed in the previous section. Secondly, Kwakman (2003), in a survey design study of 10 secondary schools in the Netherlands, showed some positive effects of teacher autonomy in decisions around the pace, method, and order of work on their participation in professional learning activities though these effects are small and thus need to be verified. Thirdly, there has been evidence on the effects of teachers' professional learning on their innovativeness and change (Clarkea & Hollingsworth, 2002; Guskey, 2002; Timperley, Wilson, Barrar, & Fung, 2007).

In brief, the conceptual model of this article proposes teacher autonomy and collaborative culture as two independent variables, collective teacher innovativeness as a dependent variable, and integrated professional learning as a mediating variable. This is a partial mediation model because it proposes that the effects of teacher autonomy and collaborative school culture on collective teacher innovativeness are both direct and indirect (*see* Baron & Kenny, 1986; Liu & Hallinger, 2020). The next section presents measurement of these variables.

4. Design and Method

4.1. Data and sample

The data are derived from the OECD Teaching and Learning International Survey 2018 (TALIS 2018, OECD 2019). We used the teacher public use file (TTGINT3) and the principal public use file (TCGINTT3). The data were gathered cross-sectionally between September 2017 and November 2018 across n = 49 countries, using a standardised teacher questionnaire. The public

use file contains data from 48 countries as Iceland has no public available data. The study, therefore, analysed the dataset collected from n = 241 426 teachers, nested in n = 15 672 schools in these 48 countries.

4.2. Measures

The dependent variable in the conceptual model of this article was labelled as *Collective Teacher Innovativeness* ($\omega = .90$). This is a latent variable based on four indicators (TT3G32A, TT3G32B, TT3G32C, TT3G32D) from the original TALIS scale of "Team Innovativeness" (T3TEAM) (*see* Appendix A). It measured teachers' perceptions of the extent to which teachers in their schools search for, develop and apply new ideas in their practices (OECD, 2019). All items were answered on a four-point Likert-type scale, ranging from "strongly disagree" to "strongly agree".

The mediating variable is a binary variable, labelled as *Integrated Professional Learning*. This is a dummy variable based on the information concerning teachers' professional development activities within 12 months prior to the time of data collection (TT3G22A to TT3G22I) (*see* Appendix A). The core question was "*During the last 12 months, did you participate in any of the following development activities*?". Three items (TT3G22A, TT3G22B, and TT3G22D) measured formal learning activities. The remaining items (TT3G22C, TT3G22E, TT3G22F, TT3G22G, TT3G22H, TT3G22I) measured job-embedded learning activities. For each of the nine items, the participants were required to choose "yes" or "no" that reflected their experience. In this article, integrated professional learning refers to teacher participation in both formal and job-embedded learning opportunities. This variable was coded as 0/1 to indicate if a teacher took part in at least one (out of the six) job-embedded and one (out of the three) formal professional learning activity during the last 12 months.

The two independent variables were labelled as *Teacher Autonomy* ($\omega = .96$) and *Collaborative Culture* ($\omega = .82$). The latent variable of *Teacher Autonomy* was based on five items (TT3G40A to TT3G40D) from the original scale of "Satisfaction with Target Class

Autonomy" (T3SATAT) (see Appendix A). The core question was "*How strongly do you agree or disagree that you have control over the following areas of your planning and teaching in this <target class>*?".

The latent variable of *Collaborative Culture* was based on three items from the original scale of "Participation among Stakeholders" (*see* Appendix A). These items (TT3G48A, TT3G48D, TT3G48E) measured the extent to which teachers participate in school-level decision-making processes and collaborate for school issues. All items were answered on a four-point Likert-type scale, ranging from "strongly disagree" to "strongly agree". The core question was "*How strongly do you agree or disagree with these statements, as applied to this school?*".

To account for potentially confounding effects, we added common demographic variables provided in the dataset of TALIS 2018 to the model of this article. The control variables at the teacher level are:

- *a) gender* (TT3G01, coded: 1: female, 2: male),
- *b) age* (TINNOVATIVENESS, coded: 1: under 25, 2: 25–29, 3: 30–39, 4: 40–49, 5: 50–59, 6: 60 and above), and
- *c) teaching experience* (TT3G11B, metric).

At the school level, the control variables are:

- a) *school size*, as indicated by the total number of students enrolled within a school (NENRSTUD, metric);
- b) *publicly- or privately-managed school* (TC3G12, coded: 1: public, 2: private);
- c) *school location – collapsed* (SCHLOC, coded: 1: Rural (up to 3,000 people), 2: Town (3001 to 100 000 people), 3: City (more than 100 000 people); and
- d) *the target populations' ISCED level* (IDPOP, coded: 1: ISCED 1 – primary education, 2: ISCED 2 – secondary education 3: ISCED 3 – tertiary education, 8:

PISA-link), which we recoded into a binary variable (primary education = 1, secondary education = 2).

Table 1 presents Mean values, SD values, and a correlation matrix of all variables at both levels of analysis. Correlations among these variables do not reveal any possible issues of multicollinearity, as shown in Table 1. Appendix A presents a full list of scales and items used in the current study.

4.3. Analytical approach

All analyses were conducted by using Maximum Likelihood (ML) in MPLUS 8.3 (Muthén & Muthén, 2019). Missing data were processed by applying the implemented Full Information Maximum Likelihood Estimators (FIML). The amount of missing data in the model variables ranged from zero to 18.7 per cent. We applied a multilevel structural equation model (MSEM) to the data for two reasons: firstly, teachers are nested in schools, and secondly we were interested testing a partial mediation model as noted above. We fitted a doubly-latent contextual model that combines a structural equation model and a multilevel model. This approach allowed us to control for measurement and sampling errors in the aggregation of individual ratings into school-level constructs to the data (full correction approach; *see* Lüdtke, Marsh, Robitzsch, & Trautwein, 2011). To facilitate interpretation and limit multicollinearity, all indicator variables were standardised (M = 0, SD = 1) prior to the estimation (Marsh et al., 2012; Morin, Marsh, Nagengast, & Scalas, 2014). All (non-essential) model covariates were defined either as within or between variables and within covariates were grand-mean centred. Appendix B presents an example of MPLUS inputs.

We simultaneously estimated all latent variables and model paths at both the teacher level (level one) and school level (level two). The latent variables at level two represent aggregates of information provided by teachers while they represent deviations from the schools' mean (the average school ratings) at level one due to implicit group-mean centring of constructs inherent in

MPLUS (Marsh et al., 2012). The dummy variable of *Integrated Professional Learning,* at level two, represents the percentage of teachers within a school that took part in professional learning activities while it represents, at level one, the individual learning experience of the surveyed teachers. Both the level one and level two components remain meaningful in and of themselves (Morin et al., 2014). Comparing the group-mean centred estimates to grand-mean centred estimates enabled us to calculate the difference between level two effects and level one effects.

The two latent constructs of *collaborative culture* and *collective teacher innovativeness* refer to the school level. These constructs are reflective measures and more meaningful at level two than those at level one since they go behind the individual experiences and represent teachers' shared perceptions of their schools (*see* Bureau, Gagné, Morin, & Mageau, 2017). At level one, these constructs tend to be less meaningful but still interpretable since they support analyses of the effects of each teacher's own individual perception. The other latent construct of *Teacher Autonomy* refers to the individual teacher and thus is a formative measure at the school level (*see* Marsh et al., 2009).

To evaluate model fit, we used three classic fit indices: comparative fit index (CFI), root mean square error of approximation (RMSEA) and standardised root mean square residual (SRMR), provided by MPLUS 8.3, to estimate the fit of the models. CFI over .90, a RMSEA less than .08 and a SRMRw / SRMRb less than .08 are generally interpreted as acceptable fit (e.g., Hu & Bentler, 1999; Marsh, Hau, & Wen, 2004).

We reported the standardised latent regression coefficients together with their corresponding standard errors, as shown in Table 3. The standardised latent regression coefficients can be interpreted as level-specific effect sizes.

Table 1. Correlation matrix of all analysed variables

		Mean	SD	Correlations										
				1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1.	Teacher Collective Innovativeness	2.99	.64	1/1										
2.	Teacher Autonomy	3.74	.77	**.06/.32**	1/1									
3.	Collaborative Culture	2.91	.60	**.44/.71**	**.01/.20**	1/1								
4.	Integrated Professional Learning	0.78	.39	**.01/.34**	**.01/.04**	**.05/.32**	1/1							
5.	Teacher Age (within only)	3.89	1.15	**.09/-**	**-.02/-**	**.03/-**	**-.03/-**	1/-						
6.	Teacher Gender (within only)	1.31	.46	**-.03/-**	**-.02/-**	.00/-	**-.03/-**	.02/-	1/-					
7.	Experience as Teacher (within only)	17.20	10.52	**.08/-**	**-.01/-**	**.03/-**	**-.01/-**	**.79/-**	**-.02/-**	1/-				
8.	School Type (between only)	1.94	.62	**-/-.19**	**-/-.04**	**-/-.15**	-/.09	-/-	-/-	-/-	-/1			
9.	Rural-Urban Profile (between only)	2.25	.73	**-/-.04**	**-/-.07**	**-/-.14**	-/-.01	-/-	-/-	-/-	**-/.03**	-/1		
10.	Public or Private School (between only)	1.22	.42	**-/.08**	-/.01	**-/-.09**	**-/.05**	-/-	-/-	-/-	**-/-.03**	**-/.24**	-/1	
11.	School Size (between only)	2.78	1.41	**-/-.09**	-/-.02	**-/-.20**	**-/.03**	-/-	-/-	-/-	**-/.13**	**-/.39**	**-/.14**	-/1

Note: All bold correlations – left: within, right: between – are statistically significant at $p<.05$.

4.4. Preliminary verification of multilevel assumptions

When applying multilevel models, it is a good practice to check if there is enough variance at all levels of the proposed model to conduct analyses and to test the interrater reliability of aggregates measured at lower levels. Our analysis explicitly, however, controls for the level of (dis)agreement among teachers in their ratings of school constructs due to the estimation process of the doubly-latent models (*see* Arens & Morin 2016). Thus, we computed the intraclass correlations in terms of ICC1 (i.e., the proportion of between-group variance to the total variance) and ICC2 (i.e., the reliability of a schools mean) of all model variables, as shown in Table 2 below. Following the recommendations by Bliese (2000), ICC1-values greater than .05 and ICC2-values greater than .70 indicate that the given construct is a group-level construct, and thus, a multilevel modelling approach should be used (*see* Lüdtke et al., 2008). Further, for all measures, we estimated rwg(j)-indexes (i.e., a measure of the interrater agreement among teachers within schools; *see* James, Demaree, & Wolf, 1984), where:

- (i) values ranging from 0 to .59 suggest an unacceptable level of interrater agreement,
- (ii) values between .60 and .69 indicate a weak level of interrater agreement,
- (iii) values between .70 to .79 indicate a moderate level of interrater agreement, and
- (iv) values equal or greater than .80 indicate as a strong level of interrater agreement (Brown & Hauenstein, 2005).

In the current study, all of the ICC1-values were rather high with *Collaborative Culture* (ICC1 = .204) and *Collective Teacher Innovativeness* (ICC1 = .156). Both of these latent variables, referring to the school level, show the highest amount of variance at the school level among the main variables. *Teacher Autonomy*, a latent variable referring to the individual teacher (ICC1 = .120), demonstrates the lowest amount of variance at the school level. The ICC1 for the mediating variable of *Integrated Professional Learning* was .134, which suggested that about 87% of the variance is located within schools. Considering the reliability of the variable means at the school

level, all ICC2-values were satisfactory *(Collaborative Culture: ICC2 = .811; Collective Teacher Innovativeness: ICC2 = .756; Teacher Autonomy: ICC2 = .695; Integrated Professional Learning: ICC2= .721)*. In addition, the rwg(j)-indexes suggested a strong level of agreement among teacher ratings within schools *(Collaborative Culture: .82; Teacher Autonomy: .87; Collective Teacher Innovativeness: .87)*. Table 2 presents ICC and rwg(j) values for all main variables, along with omega reliability values.

Table 2. ICCs, reliability and interrater agreement of main variables

	ICC1	ICC2	rWG(J)	Omega
Collective Teacher Innovativeness	.156	.756	.871	.901
Collaborative Culture	.204	.811	.819	.820
Teacher Autonomy	.120	.695	.873	.964
Integrated Professional Learning	.134	.721	NIL	NIL

Note. *ICC= Intraclass correlation coefficients.*

To examine if all latent variables were measured in the same way at both levels of analysis, we finally tested for multilevel invariance by constraining all factor loadings equally across levels and fixing the between level residual variances to zero (Guenole, 2018; Jak et al. 2013). With χ^2 = 62018.165(df =147), p<.001, CFI= .97, RMSEA = .04, SRMRw = .02 and SRMRb = .11. This model fitted the data well. Freeing the residual variance at the school level resulted in a slightly better model fit (χ^2= 21939.876(df =135), p<.001, CFI= .99, RMSEA = .03, SRMRw = .02 and SRMRb = .08). Thus, all factor loadings can be considered equal, relatively invariant across levels (Jak et al., 2013).

Table 3

Results of the Multilevel Structural Equation Model for Collective Teacher Innovativeness.

	β	*(S.E)*	*p*
Within (teacher level)			
Collaborative Culture -> Collective Teacher Innovativeness	.433	.005	.000
Teacher Autonomy -> Collective Teacher Innovativeness	.016	.003	.000
Integrated Professional Learning -> Collective Teacher Innovativeness	-.011	.002	.000
Collaborative Culture -> Integrated Professional Learning -> Collective Teacher Innovativeness	-.001	.000	.000
Teacher Autonomy -> Integrated Professional Learning -> Collective Teacher Innovativeness	.000	.000	.124
R^2		.199	
Collaborative Culture -> Integrated Professional Learning	.049	.003	.000
Teacher Autonomy -> Integrated Professional Learning	.004	.003	.101
R^2		.004	
Between (school level)			
Collaborative Culture -> Collective Teacher Innovativeness	.641	.011	.000
Teacher Autonomy -> Collective Teacher Innovativeness	.179	.011	.000
Integrated Professional Learning -> Collective Teacher Innovativeness	.133	0.11	.000
Collaborative Culture -> Integrated Professional Learning -> Collective Teacher Innovativeness	.046	.004	.000
Teacher Autonomy -> Integrated Professional Learning -> Collective Teacher Innovativeness	-.004	.002	.059
R^2		.584	
Collaborative Culture -> Integrated Professional Learning	.348	.013	.000
Teacher Autonomy -> Integrated Professional Learning	-.027	.014	.053
R^2		.115	

Notes. 1. *The model has been controlled for by the following variables: Age, experience, and gender at individual teacher level as well as school size, type of school, ISCED level, and school location at school level* two. *Results from the ML-SEM, direct and indirect effects (standardised).*

5. Results

In the first step, we evaluated the fit of the proposed model to the data of TALIS 2018. The fit indexes showed that the model and the data coincided well ($\chi^2 = 20677.383$ (df =190), p<.001, *CFI* = .99, *RMSEA* = .02, $SRMR_w$ = .01, $SRMR_b$ = .04). In the second step, we inspected the path coefficients among the model variables at both levels. This section presents results from analyses at the teacher (level one) and school levels (level two) (*see* Table 3).

5.1 Results from analyses at teacher level (level one)

Analyses at the teacher level found a strong positive relationship between collaborative culture and collective teacher innovativeness (β=.433, *SE*=.005, p<.001). It meant that teachers' perceptions of collaborative culture in their school were significantly associated with those of their school's collective innovativeness.

Teacher autonomy was identified to be a positive predictor of collective teacher innovativeness (β=.016, *SE*=.003, p<.001). This suggested that teachers' individual perceptions of own autonomy influenced their perceptions of collective innovativeness in their school.

Teacher autonomy and collaborative culture were significantly related to each other at level one (r=.099, *SE*=.003, p<.001). While teachers' individual perceptions of collaborative culture increased, the perceptions of their own autonomy tended to increase, and vice-versa.

Teacher autonomy was not significantly related to integrated professional learning (β=.004, *SE*=.003, p>.05). Teacher autonomy, therefore, had no indirect effects on collective teacher innovativeness at level one.

Collaborative school culture had a significant and positive relationship with integrated professional learning (β=.049, *SE*=.003, p<.001). Integrated professional learning was found to be related negatively to teachers' perceptions of innovativeness in their school (β=-.011, *SE*=.002, p<.001). As noted earlier, collective teacher innovativeness in this study was measured by teachers' perceptions about the innovativeness of their school as a whole. This result implied that

teachers who got involved in integrated professional learning, including both formal and job-embedded professional learning activities, tended to perceive their school as less innovative. These results showed a statistically significant indirect effect of collaborative school culture on collective teacher innovativeness (β=-.001, *SE*=.000, p<.001) though this effect was negative and very small.

Controlling variables on the dependent variable at level one, we found that both age (β=.066, *SE*=.004, p<.001) and experience (β=.018, *SE*=.004, p<.001) were positively associated with teachers' perceptions of collective innovativeness. Male teachers tended to rate the degree of collective innovativeness in their schools (β=-.033, *SE*=.002, p<.001) lower than female teachers.

5.2. Results from analyses at school level (level two)

The analyses at the school level found that collaborative culture was significantly associated with collective teacher innovativeness (β=.641, *SE*=.011, p<.001). Those teachers who worked in a highly collaborative school environment tended to be more innovative as perceived by their colleagues.

Similarly, the overall perception of teacher autonomy was significantly associated with that of collective teacher innovativeness (β=.179, *SE*=.011, p<.001). This could be interpreted that teachers' rating of the degree of their own classroom autonomy in a school (as average of all teachers' individual perceptions) was slightly related to their collective innovativeness in that school.

At level two, teacher autonomy was not significantly associated with integrated teacher professional learning (β=-.027, *SE*=.014, p>.05). There was no indirect relationship between teacher autonomy and collective teacher innovativeness at level two, which was similar to the results at level one.

On the contrary, collaborative culture was found to be significantly related to integrated professional learning (β=.348, *SE*=.013, p<.001). The current study also found a significant positive relationship between integrated teacher professional learning at the school level and

collective teacher innovativeness (β=.133, *SE*=.011, p<.001). In other words, collective teacher innovativeness tended to be considerably higher when the overall participation in professional learning increased as a whole in that school, i.e., more teachers in the same school participated in both formal and job-embedded professional learning activities. These results highlighted a statistically significant positive indirect effect of collaborative school culture on collective innovativeness (β=.046, *SE*=.004, p<.001).

In addition, there was a significant relationship between teacher autonomy and collaborative school culture (*r*=.194, *SE*=.012, p<.001). While the degree of perceived collaborative school culture increased, teachers' overall perception on their autonomy increased, and vice versa.

All four controlling variables (i.e., school size, school type, school location, and ISCED level) were significantly related to collective teacher innovativeness. Firstly, school size was positively associated with collective teacher innovativeness (β=.026, *SE*=.009, p<.001). Teachers' perceptions of collective innovativeness in their school increased with the size of the school.

Secondly, school type was significantly related to collective teacher innovativeness. This indicated that teachers working in private schools had significantly higher perceptions of their schools' collective innovativeness (β=.135, *SE*=.009, p<.001) than those working in public schools.

Thirdly, school location was positively associated with collective teacher innovativeness (β=.018, *SE*=.009, p<.05). Teachers working at schools located in larger cities had higher perceptions of their schools' collective innovativeness.

Fourthly, there was a negative relationship between schools' ISCED level and collective teacher innovativeness (β=-0.094, *SE*=0.012, p<0.001). Secondary schools had a lower degree of collective innovativeness as compared with primary schools, according to the perceptions of teachers.

In the final step, we checked for appropriate contextual effects of integrated professional learning and teacher autonomy on collective teacher innovativeness by subtracting the level one from the level two effect and standardising these differences (*see* Morin et al., 2014). This additional parameter is identical to what would have been obtained under a grand-mean centring procedure. It showed that a unique and statistically significant effect at the school level was observable regarding professional learning (β=.083, p=<0.001) and teacher autonomy (β=.047, p=<0.001).

6. Discussion and conclusions

The Results section highlights four prominent findings of this article. *Firstly*, teachers' perceptions of their classroom autonomy and those of collaborative culture in their school were significantly related to each other. *Secondly*, both teacher autonomy and collaborative culture were significantly and directly associated with teachers' perceptions of collective innovativeness in their schools at both the teacher (level one) and school (level two) levels. *Thirdly*, no significant indirect effects of teacher autonomy on collective teacher innovativeness, mediated by integrated teacher professional learning, were found in this study at any level. *Fourthly*, the results showed a statistically significant indirect effect of collaborative culture on collective teacher innovativeness through integrated professional learning at both the teacher and school levels. While integrated professional learning mediated the indirect effect of collaborative culture on collective teacher innovativeness positively at the school level, this mediation effect tended to be negative at the individual teacher level. Before discussing major implications of these findings, it is important to highlight some of the limitations and to suggest further research to complement this study.

6.1. Limitations and suggestions for future research

The dataset of TALIS 2018 used in this article was based on teachers' perceptions as a single source of data and collected at one time. The retrospective and self-perceptual nature of the data might limit the validity of some measures used in this study, given potential recall biases (*see*

Schwarz, 2007). A part of the variance in the model might be attributable to the measurement method rather than to the constructs measured because a potential single source bias is likely to threaten "the validity of the conclusions about the relationship between measures" (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003, p. 879). While this cross-sectional study does not allow strong claims on temporary causality, it supports testing a mediational effect from a statistical perspective that highlights possible mechanisms of effects of teacher autonomy and collaborative culture on collective teacher innovativeness (*see* Baron & Kenny, 1986; David & Sava, 2015). A good combination of future time-series, longitudinal, and in-depth case study research would complement this study in modelling and evaluating the potential dynamics and reciprocal relationships among relevant variables and providing more insights into collective innovativeness.

As noted in the Methods section, the current article draws upon an analysis, using sophisticated statistical methods, of available large-scale data. Each construct in this article was measured by one single scale. Although the scales used in this article are supported by the literature as discussed in the previous sections, it is unlikely that they cover all factors or facets of each construct. For example, the construct of teacher autonomy in this study measured teachers' perceptions of five domains within classroom autonomy, and thus excluded the other levels and domains of autonomy (*see* Salokangas & Wermke, 2020). This article follows a good practice of providing clarity on which factors, variables, and items were examined. Future research could build on this article to measure each construct in more depth and comprehensiveness.

In addition, this article centres on investigating the effect mechanisms of teacher autonomy, collaborative culture, and professional learning on collective teacher innovativeness, given the complexity of the current conceptual model. Future research could examine the effects of other potential factors, for example, school leadership (Robinson, Lloyd, & Rowe, 2008), teacher efficacy (Schwabsky, Erdogan, & Tschannen-Moran, 2019) and trust (Schwabsky,

Erdogan, & Tschannen-Moran, 2019) on collective innovativeness in school, using TALIS datasets and beyond.

The scope and space of this article justify a choice of focusing on sophisticated analyses of the TALIS data as an aggregated, decontextualised dataset across 48 countries. This approach is similar to that of some previous articles (e.g., Fackler & Malmberg, 2016; Vieluf, Kunter, & Van de Vijver, 2013). For example, Fackler and Malmberg (2016) analysed TALIS 2007 data collected from 14 OECD countries to examine the factors influencing teacher self-efficacy. While the approach of the current study extends the geographical locus of previous research on teacher innovativeness, subsequent studies could further leverage OECD datasets by conducting methodologically comparative analyses around this topic between countries and regions.

All controlling variables at each level of analysis in this study, as reported in the Results section, were found to be significantly related to teachers' perceptions of collective innovativeness in their schools. Although the current survey data offer no firm basis for any meaningful explanations of such relationships, these findings may provide clues for future research focusing on the interactions of demographic factors and school types, location, and level and teacher innovativeness.

6.2. Interpretation and implications of findings

The current article supports the aforementioned proposition that teacher classroom autonomy and collaborative school culture are positively interconnected. The empirical literature has documented classroom autonomy and collaboration as important stimulants to teachers' positive affective factors such as teacher professional engagement, teacher job satisfaction and motivation, and teacher efficacy (Dou, Devos, & Valcke, 2017; Scheopner, 2010; Skaalvik & Skaalvik, 2011, 2014; Strong & Yoshida, 2014). Nevertheless, there has been a tendency to conceptualise teacher autonomy and collaboration as two opposite constructs: autonomy tends to be connoted with independence or individualism (Street & Licata, 1989) that is theoretically opposite to the

interdependence of collaboration (Vangrieken, Grosemans, Dochy, & Kyndt, 2017). The results at both the teacher and school levels show that a culture of collaboration between and among teachers and other actors in schools do not preclude teachers' classroom autonomy. Furthermore, two of the three items in the scale of collaborative culture in this study aimed to investigate the extent of participative, shared decision-making in schools. Teacher participation in school decision-making processes is likely to give teachers a sense of more professional control that is the core characteristic of autonomy (Dikilitas & Mumford, 2019; Evans & Fischer, 1992). Similarly, teachers with a greater sense of classroom autonomy tend to be more open to get involved and share responsibilities for school-wide issues (Buske, 2018). These results allow a theoretical implication that autonomy and collaboration are two distinguishable albeit interrelated constructs.

Despite the interconnectedness between teacher autonomy and collaborative culture, their pathways and extent of effects on collective teacher innovativeness are differentiated. The statistical results suggest a positive albeit small effect of teacher classroom autonomy on collective teacher innovativeness at both the teacher and school levels. Teachers with higher perceptions of their own classroom autonomy tend to rate their school's collective innovativeness stronger. The contextual effect of teacher autonomy on collective innovativeness, as identified at the school level, suggests that working with colleagues who have higher perceptions of their own classroom autonomy would increase teachers' collective innovativeness perceptions of their school. This finding implies the need of defending or enhancing teacher autonomy in making decisions on the issues of subject content, instructional methods, and assessment. The degree of autonomy given to teachers should be sensitive to that of teachers' readiness and each country's context (OECD, 2020). This implication is aligned with the literature on the benefits of teacher autonomy in promoting educational initiatives and teacher job satisfaction, commitment, and professional

engagement (Cribb & Genwirtz, 2007; Deci & Ryan, 2008; Skaalvik & Skaalvik, 2014; Worth & Van den Brande, 2020).

It is noteworthy that the analyses at both the teacher and school levels show no significant effects of teachers' perceived classroom autonomy on their participation in professional learning activities within and outside their schools. Interpretation of this finding should take two methodological factors into account. Firstly, the scale of teacher autonomy in TALIS 2018 focuses on measuring teachers' perceptions of autonomy in the issues of their course content, instructional methods, and assessment, and thus excludes the issues beyond classroom level that may influence their participation in professional learning such as teacher autonomy in participating professional development types and activities. Secondly, this article centres on an integration of formal and job-embedded teacher professional learning, as elaborated in the previous sections. An alternative approach of measuring these two types of professional learning distinctively may result in a different pattern of findings. For example, Kwakman (2003) found a small, positive effect of teacher professional autonomy on their participation in job-embedded professional learning in schools.

The analyses at both the teacher and school levels show that the extent of direct, positive effects of collaborative school culture on collective teacher innovativeness is substantially greater than that of teacher classroom autonomy. To put it simply, it is implied that teachers are more receptive to innovations in schools with a strong culture of teacher collaboration and participation in school-wide decision-making processes. This finding is logically meaningful and critical in promoting implementation of initiatives in schools. It reinforces the vitality of building and maintaining a positive culture of mutual support, cognitively and affectively, in promoting initiation, implementation and diffusion of innovations (Nguyen, Harris, & Ng, 2019; Nguyen & Ng, 2020).

This article evidences complexities in the pathways that integrated professional learning mediates the relationship between collaborative culture and collective teacher innovativeness. Teachers' integrated professional learning would mediate the relationship between collaborative school culture and collective teacher innovativeness positively at the school level but negatively at the teacher level. More specifically, the analyses at the school level indicate that teachers' average rating of collaborative culture in a school is positively related to their participation in integrated professional learning, which in turn is positively associated with their average perceptions of innovativeness of their school.

The contextual effect of integrated professional learning, as reported in the Results section, suggests that teachers working with colleagues who have a higher level of participation in professional learning activities tend to be more positive about the degree of their schools' collective innovativeness. The analyses at the teacher level, however, show that teachers' perception of collaborative school culture is positively linked with their participation in integrated professional learning, but teachers' individual participation in integrated professional learning is negatively related to their perceptions of collective innovativeness.

These results could be interpreted as *firstly*, the collaborative culture of a school would encourage more teachers of the school to participate in professional learning activities, which would increase collective teacher innovativeness; and *secondly*, teachers' individual participation in integrated professional learning would have no significant effects or a minimal, negative effect on their perceptions of collective teacher innovativeness in their school. This negative effect could be attributable to the possibilities: (i) that a few teachers exposed to innovative ideas as a result of their individual participation in learning opportunities feel the need of enhancing the collective innovativeness of their own school; or (ii) that those individual teachers face their colleagues' resistance to their innovations inspired from their participation in professional learning activities. Although this interpretation could be specifically verified in future research, it does imply the

benefit of collective participation of groups of teachers from the same school in professional learning activities to promote collective teacher innovativeness. Such collective participation would be helpful in establishing receptivity and sustain implementation of innovations in a school since teachers are exposed to the common types and content of learning opportunities and more likely to reach a consensus about an innovative approach for improvement (Desimone, 2009; Garet et al., 2001). Collective teacher participation in job-embedded professional learning is potentially promoted through developing inclusive professional learning communities within and across schools (Nguyen & Ng, 2020; Stoll et al., 2006) and, where possible, organising effective professional development courses and workshops for groups of teachers from the same school (Garet et al., 2001).

In conclusion, the current article calls attention for developing and maintaining a positive culture of collaboration, mutual support, collective teacher participation in professional learning, and respecting teacher classroom autonomy while maintaining a good level of support for teacher development, to promote collective innovativeness in schools. Collective teacher innovativeness is a construct of international relevance and a critical condition for transforming schools into innovative organisations that nurture creativity of teachers and students. Looking forwards, more rigorous empirical and theoretical research relevant to collective teacher innovativeness should be developed timely to establish a strong knowledge base to support innovative teaching and learning in schools.

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Appendix A. Items and scales used in the current study.

Teacher Autonomy

TT3G40: How strongly do you agree or disagree that you have control over the following areas of your planning and teaching in this <target class>?

Response options: "Strongly disagree" (1), "Disagree" (2), "Agree" (3), "Strongly agree" (4).

Items:

TT3G40A. Determining course content

TT3G40B. Selecting teaching methods

TT3G40C. Assessing students' learning

TT3G40D. Disciplining students

TT3G40E. Determining the amount of homework to be assigned

Collaborative Culture

TT3G48: How strongly do you agree or disagree with these statements, as applied to this school?

Response options: "Strongly disagree" (1), "Disagree" (2), "Agree" (3), "Strongly agree" (4).

Items:

TT3G48A. This school provides staff with opportunities to actively participate in school decisions.

TT3G48D. This school has a culture of shared responsibility for school issues.

TT3G48E. There is a collaborative school culture which is characterised by mutual support.

Integrated Professional Learning

TT3G22: During the last 12 months, did you participate in any of the following professional development activities?

Response options: "Yes" (1), "No" (2)

Items:

TT3G22A. In-person courses seminars

TT3G22B. Online courses seminars

TT3G22C. Education conferences

TT3G22D. Formal qualification programme

TT3G22E. Observation visits to other schools.

TT3G22F. Observation visits to business premises.

TT3G22G. Peer and/or self-observation and coaching.

TT3G22H. Participation in a network of teachers formed specifically for the professional development of teachers.

TT3G22I. Reading professional literature.

Collective Teacher Innovativeness

TT3G32: Thinking about the teachers in this school, how strongly do you agree or disagree with the following statements?

Response options: “Strongly disagree” (1), “Disagree” (2), “Agree” (3), “Strongly agree” (4).

Items:

TT3G32A. Most teachers in this school strive to develop new ideas for teaching and learning.

TT3G32B. Most teachers in this school are open to change.

TT3G32C. Most teachers in this school search for new ways to solve problems.

TT3G32D. Most teachers in this school provide practical support to each other for the application of new ideas.

Appendix B. Example of MPLUS Syntax.

```
Title: Collective Teacher Innovativeness

Data: File is talis.dat;
Format is f10.0, f8.0, f6.0, 21f1.0, f3.0;

  Variable: Names are
IDTEACH IDSCHOOL IDCNTRY
TT3G01
TT3G32A TT3G32B TT3G32C TT3G32D
TT3G40A TT3G40B TT3G40C TT3G40D
TT3G40E
TT3G48A TT3G48D TT3G48E
devcom
IDPOP
SCHLOC
TC3G12
```

```
NENRSTUD
TCHAGEGR
devinfo
devform
TT3G11B;

within =  TCHAGEGR TT3G01 TT3G11B;
between = IDPOP SCHLOC TC3G12 NENRSTUD;

Usevariables are
TT3G32A TT3G32B TT3G32C TT3G32D
TT3G40A TT3G40B TT3G40C TT3G40D
TT3G40E
TT3G48A TT3G48D TT3G48E
IDPOP SCHLOC TC3G12 NENRSTUD
TCHAGEGR TT3G01 TT3G11B
devcom;


IDVariable is IDTEACH;
Cluster is IDSCHOOL;

Missing are all (7, 8, 9, 997-999);


Define:

Standardize
TT3G32A TT3G32B TT3G32C TT3G32D
TT3G40A TT3G40B TT3G40C TT3G40D
TT3G40E TT3G48A TT3G48D TT3G48E;

centering = Grandmean(TCHAGEGR TT3G01 TT3G11B);

Analysis:
Processors=3;
Type = twolevel;

Model:
%within%
inno_w by TT3G32A@1 (101);
inno_w by TT3G32B (102);
inno_w by TT3G32C (103);
inno_w by TT3G32D (104);

auton_w by TT3G40A@1 (401);
auton_w by TT3G40B (402);
auton_w by TT3G40C (403);
auton_w by TT3G40D (404);
auton_w by TT3G40E (405);

clima_w by TT3G48A@1 (501);
clima_w by TT3G48D (504);
clima_w by TT3G48E (505);

inno_w on devcom (w901);
inno_w on auton_w  (w903);
inno_w on clima_w  (w905);
```

```
devcom on auton_w  (w910);
devcom on clima_w (w911);

inno_w on TCHAGEGR TT3G01 TT3G11B;
auton_w on TCHAGEGR TT3G01 TT3G11B;
clima_w on TCHAGEGR TT3G01 TT3G11B;
devcom on  TCHAGEGR TT3G01 TT3G11B;

auton_w with clima_w;

!model indirect:
!inno_w ind devcom;

%between%

inno_b by TT3G32A@1 (101);
inno_b by TT3G32B (102);
inno_b by TT3G32C (103);
inno_b by TT3G32D (104);

auton_b by TT3G40A@1 (401);
auton_b by TT3G40B (402);
auton_b by TT3G40C (403);
auton_b by TT3G40D (404);
auton_b by TT3G40E (405);

clima_b by TT3G48A@1 (501);
clima_b by TT3G48D (504);
clima_b by TT3G48E (505);

inno_b on devcom (b901);
inno_b on auton_b  (b903);
inno_b on clima_b  (b905);

devcom on auton_b  (b910);
devcom on clima_b (b911);

inno_b on IDPOP SCHLOC TC3G12 NENRSTUD;
auton_b on IDPOP SCHLOC TC3G12 NENRSTUD;
clima_b on IDPOP SCHLOC TC3G12 NENRSTUD;
devcom on IDPOP SCHLOC TC3G12 NENRSTUD;

auton_b with clima_b;

inno_b (varop);

model indirect:
inno_b ind auton_b;
inno_b ind clima_b;

inno_w ind auton_w;
inno_w ind clima_w;

model constraint:
new(c_effect);
c_effect = b901-w901;
```

```
new (devc_w);
new (devc_b);
devc_w=0.574;
devc_b=0.112;

new(c_effect_stdxy);
c_effect_stdxy = c_effect*(sqrt(varop)/sqrt(devc_w+devc_b));

new (c1_effect);
c1_effect = b903-w903;

new (aut_w);
new (aut_b);
aut_w=0.652;
aut_b=0.090;

new(c1_effect_stdxy);
c1_effect_stdxy = c1_effect*(sqrt(varop)/sqrt(aut_w+aut_b));

Output: Tech1 Tech4 Tech8 Standardized;
```