What makes a difference in teacher innovativeness? Evidence from the TALIS 2018 US teacher data

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Abstract

Purpose – This study looked into the factors that could make a difference in teachers' individual innovativeness and team innovativeness. We investigated five categories of factors: (1) innovation-related teacher preparedness, (2) innovation-related teacher professional development, (3) teacher professional practices, (4) teacher empowerment and (5) innovation-related teacher self-efficacy.

Design/methodology/approach – The data source is the 2018 Teaching and Learning International Survey (TALIS) US data. The samples include about 165 schools and 2,560 teachers. We applied the structural equation model to analyze the data and the unit of analysis is set at the individual teacher-level.

Findings – We found that all factors matter except professional development and that they matter differently for different innovativeness outcomes.

Originality/value – This study is significant in several aspects: first, it is among the first that examined the factors that could make a difference in teacher innovativeness. Second, we differentiated between individual and team teacher innovativeness. Third, the findings highlight the importance of several factors including teacher preparation, teacher collaboration, teacher participation in school decisions and teacher self-efficacy.

Keywords Teacher innovativeness, Teacher preparedness, Professional development, Professional practices, Teacher empowerment, Teacher self-efficacy

Paper type Research paper

1. Introduction

Schools are tasked with equipping students for their future with the knowledge and skills necessary to thrive as the local and global society members (World Economic Forum, 2020). To prepare the students to be future-ready, teachers and school systems are under pressure to design innovative lessons that engage students in ways that focus on problem-solving, collaboration and knowledge construction (Koh *et al.*, 2015). To address this need, concepts including innovation-related professional development (PD) and preparation have been utilized to enhance innovation in schools (Le Donné *et al.*, 2016). However, little evidence-based research has examined essential agendas, such as what makes a difference in teacher innovativeness.

While similar concepts, there are key differences between innovation and innovativeness. Innovativeness has been defined based on the employees' perception that their work environment is open for innovation and change (Patterson *et al.*, 2005). In their review of the

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definitions of creativity and innovation, Hughes *et al.* (2018) carefully examined how the field has come to define innovation. The authors explained,

> Workplace innovation concerns the processes applied when implementing new ideas. Specifically, innovation involves some combination of problem/opportunity identification, the introduction, adoption or modification of new ideas germane to organizational needs, the promotion of these ideas and the practical implementation of these ideas. (p. 551)

This definition applies to our study as it is not outcome-based. Much of the literature on innovation refers to what it does or changes. Based on our study's research design and questions, an outcome-based definition would not be as appropriate.

Innovativeness, therefore, differs from innovation as it is a prerequisite for innovation to happen in a setting. Along this line, the OECD (2019a, b) differentiates between the concepts by expressing that innovativeness is the precursor to innovation. Organizational innovativeness is how the school "provides (s) a conducive environment for innovative practices" (p. 4). The implementation of these practices themselves then defines innovation. We are not measuring the extent to which these practices are utilized in a particular school but examining what conditions provide a conducive environment for implementing these practices.

The primary aim of this study is to understand to what extent school factors make a difference in teacher innovativeness. Focusing on both the individual and team levels of teacher innovativeness measures, we identified five groups of school factors: (1) innovation-related teacher preparedness, (2) innovation-related teacher PD, (3) teachers' professional practices, (4) teacher empowerment and (5) innovation-related teacher self-efficacy (TSE). The following section reviewed the existing research literature on factors that impact teachers' innovativeness. We then presented a conceptual framework to guide the study.

2. Review of literature

The focus on innovativeness is problematic as, despite the significant role of numerous studies on innovativeness in education, we still need a unanimously agreed-upon definition in the field of teacher education (Ainley and Carstens, 2018). For this study, we utilize the Teaching and Learning International Survey (TALIS) (2012) definition of a new idea or a further development of an existing product, process or method applied in a specific context to create a value-added. Similar to the work of Tang (2021), we see innovativeness as the use of new ideas, methods and practices for teaching and learning at school. From this definition, we can gain a more holistic understanding of the practices teachers and teams implement in their settings to be innovative. One example of trying to understand better the construct of innovativeness is to examine the factors that promote it. One recent study by Açikgül Firat and Torun (2022), studied preservice teacher risk-taking as a predictor of their innovativeness. In the study, the authors found that risk-taking behaviors such as intellectual and academic risk-taking were critical to teacher innovativeness. This finding is aligned with that of Pierre (2015), who explained that risk-taking behavior also contributes to positive learning experiences through developing creativity, innovation and critical thinking. These findings show that there are significant predictors of educator innovativeness and that others should be explored. Through this understanding, we looked at specific factors associated with individual teacher innovativeness (ITI) and teachers' team innovativeness (TTI); innovation-related teacher preparation; innovation-related teacher PD; innovation-related professional practices; teacher empowerment and innovation-related TSE.

2.1 Individual teacher innovativeness

As measured by TALIS (2018), teacher innovativeness examines practices that enhance student cognitive activation. Cognitive practices can be thought of as ones that deviate from the traditional lecture model and seek to develop high-level skills for students (Le Donné *et al.*, 2016). Considering Bloom's taxonomy, the students are asked to move beyond knowledge regurgitation and think critically to find an answer. According to OECD (2019a, b), cognitive activation is characterized by tasks requiring students to think critically, ask students to decide on procedures for solving complex tasks or present tasks for which no obvious solution exists.

Though the notion of what is innovative may seem more complex than this broad definition, it is clear that there is a need for a baseline understanding of the extent to which these practices are used (O'Shea, 2021). Echazarra *et al.* (2016) found that only one-third of the students were exposed to these teaching practices in an international study like this one. Utilizing these practices can then move beyond the classroom and foster a school-level climate of innovativeness (Blömeke *et al.*, 2021).

2.2 Team innovativeness

Beyond examining a single teacher's innovativeness, how the school promotes a culture of innovation is critical (Blömeke *et al.*, 2021). Team innovativeness in an educational setting differs from similar topics such as teacher collaboration. Also conceptualized as collective innovativeness, team innovativeness focuses less on the traditional models of collaboration, where the simple organization of teachers into departments sufficed and moves into how teachers support one another, identify new ways of teaching and learning and their openness to change (Meirink *et al.*, 2010). These factors then allow a school's culture to adapt to the contextual needs.

The value of a positive school culture for team innovativeness is exemplified in a study by Nguyen *et al.* (2021). In their study of the same dataset used, the authors found that the effect of collaborative school culture was substantially greater than the effect of teacher autonomy. The finding illustrates that teachers' innovativeness is far higher in schools with greater levels of teacher collaboration. Though collaborative school culture and teacher-classroom autonomy are positively interconnected, teacher autonomy is less influential to team innovativeness than the building of mutual respect, support and vulnerability (Nguyen *et al.*, 2021).

2.3 Factors that could make a difference in teacher innovativeness

2.3.1 Innovation-related teacher preparation. Many factors could play a role in teacher innovativeness. One such factor is teacher preparation. This factor can require a shift due to changing tools and evolving student educational outcomes such as digital literacy (Dumont and Istance, 2010). Teacher preparation is an important component of innovativeness, as the formal training preservice teachers receive often needs to be improved for their classroom teaching (Ainley and Carstens, 2018). Crossan and Apaydin (2010) identified three areas of innovation in teacher preparation: organizational structure, organizational processes and organizational outcomes. The focus on these areas reaffirms our understanding of the differences between innovation and innovativeness. Castro and Edwards (2021) utilized these domains to conduct an exploratory study of innovative teacher preparation programs in Texas, as Texas prepares the most teachers in the country. Their findings show that most programs demonstrated few indicators of innovativeness even though they met requirements for accountability and accreditation. Their results highlight the need for change as the authors explained, "Rather, most Teacher Preparation Programs (TPPs) in Texas

exemplified characteristics of isomorphism, in that, the absence of innovation led to overall program similarity across the typologies" (p. 21).

To avoid this isomorphism, innovative teacher preparation programs can highlight the importance of teaching cross-curricular skills (CCS) such as creativity, critical thinking and problem-solving while utilizing information and communication technology (ICT) to enhance the lessons that educators deliver (O'Shea *et al.*, 2022). The importance of innovative teacher preparation should be recognized, as teaching across curricular domains also fosters the ability to develop authentic learning encounters across lines of social difference (Morales *et al.*, 2020). As teachers are prepared more innovatively, they may feel more confident in their innovativeness and ability to teach in innovative-charged classrooms (O'Shea *et al.*, 2022).

2.3.2 Innovation-related teacher PD. To address the gaps in their formal training, many educators seek PD opportunities to enhance their instructional practices. Teacher PD is critical to enhancing teacher quality and student outcomes (Darling-Hammond *et al.*, 2017). Zhang *et al.* (2021) pointed out that PD is essential for all teachers, veteran and new. When considering the isomorphism of most teacher preparation programs (Castro and Edwards, 2021), this similarity emphasizes the need for PD to adjust to the current needs of students and educators.

This need is illustrated in the work of Silver *et al.* (2019), who examined teacher PD and its relation to pedagogical innovativeness. Their study found that professional practices, development and efficacy ultimately lead to pedagogical innovation. These professional practices are more encompassing than previously thought as they are developed through teacher preparation and PD and go beyond the practices teachers are exposed to; they also dynamically shape teachers' self-efficacy (Ainley and Carstens, 2018). Though many new and veteran teachers need more PD opportunities to learn more about innovative ways to engage and assess students (Ornstein and Hunkins, 2013), collaborative teacher PD remains limited (Lucilio, 2009).

2.3.3 Innovation-related teacher professional practices. One way in which teachers can enhance their instructional practices beyond PD opportunities is through their cooperation and exchange with colleagues in their settings. In their seminal studies, Little (1990) and Rosenholtz (1989) outlined four dynamics of team member collaboration: "storytelling and scanning," "aid and assistance," "sharing or exchange of instructional materials and ideas" and "joint work" or "instructional problem-solving and planning." The third level, sharing or exchanging instructional materials, is what many educators currently enact in professional learning communities (PLCs), where materials are shared and lesson plans and schedules are conducted. The highest level of this collaboration is characterized by teachers working together for a common cause and adjusting their instruction to match each other in an agreed-upon way. Meirink *et al.* (2010) utilized these frames to analyze the relationship between teacher learning and collaboration to understand better how the dynamics influenced teacher team innovativeness. The authors found that for collaboration and exchange to be effective, teachers required autonomy in deciding the topics and how these practices were employed. This highlights a critical element as collaboration goes beyond exchanging materials but requires collaborative professional learning and teacher empowerment.

2.3.4 Teacher empowerment. Considering the value of teacher empowerment in teacher innovativeness is essential and cannot be understated (Calibayan, 2015). To develop an environment, this type of environment requires buy-in from educators across levels (Le Donné *et al.*, 2016). Similarly, Wagner (2012) notes that innovative environments exhibit strong teamwork, interdisciplinary problem-solving and empowerment cultures, utilizing the original teacher empowerment work of Short *et al.* (1994), we define teacher empowerment as teachers' ability to take charge of their personal and PD and growth

while gaining the capacity to take on decision-making roles to increase opportunities for meaningful collective participation (Short *et al.*, 1994). In this, we conceptualize teacher empowerment similarly to that of TALIS (2018), where empowerment comprises two subcategories: teacher-classroom autonomy and teacher-school decision participation.

Teacher empowerment: classroom autonomy. Along the same vein of self-efficacy, teacher autonomy is a complex and multidimensional construct. Recent literature on classroom autonomy views it as having the freedom and capacity to make decisions and act independently (Mausethagen and Mølstad, 2015; Worth and Van den Brande, 2020). Vangrieken *et al.* (2017) identify two aspects of teacher classroom autonomy: didactical pedagogical autonomy and curricular autonomy. Didactical pedagogical autonomy refers to preparing lessons, teaching methods, student assignments and managing student behavior. Curricular autonomy pertains to decisions about curriculum and setting goals for students. This curricular autonomy allows teachers to make decisions that they believe will better serve their students (Webb, 2002). From this curricular perspective, O'Shea (2021) explained that increased levels of autonomy are a statistically significant predictor of teachers' use of innovative teaching practices. The author found that when teachers are empowered to make educated decisions in their classrooms, the frequency in which they use innovative practices, increased significantly. These findings support the consideration that teacher-classroom autonomy is critical in concerns to innovativeness.

For this article, we think of classroom autonomy as similar to Vangrieken *et al.* (2017) example of curricular autonomy. We will follow OECD's (2019a, b) guidance on operationalizing classroom autonomy as teachers' ability to determine course content, select specific teaching methods, assess student learning and student discipline and determining the amount of homework assigned.

Teacher empowerment: school decision participation. Shared decision-making and participation are fundamental to developing an innovative-rich environment (Nguyen *et al.*, 2021). Nguyen *et al.* (2021) pointed out that a school culture of teacher collaboration and participation in school-wide decision-making is the key to teachers and building innovativeness. This finding is consistent with the work of O'Shea (2021), who identified that teachers are more likely to utilize innovative teaching practices in their classrooms when principals allow for more teacher autonomy through participation in the decision-making process. This is the key to this study as it illustrates the relationship between participation, autonomy and team innovativeness. To enhance team innovativeness in an educational setting, school leaders need to work to build a collaborative culture that values community support and the implementation and diffusion of innovations (Nguyen *et al.*, 2019; Nguyen and Ng, 2020).

2.4 Innovation-related TSE

The initial belief that one can make change is paramount to innovation, as lower levels of self-efficacy can serve as a barrier. Cai *et al.* (2017) found that teachers with lower levels of self-efficacy were less likely to utilize innovative instructional practices, such as technology infusion, even when they believed it would benefit their students. TSE has also drawn attention to fostering innovativeness, as efficacy has been shown to foster collaborative school cultures (Bangs and Frost, 2012). Interestingly, in their recent study of creative teacher self-efficacy (CTSE), Park *et al.* (2021) explained that "A high CSE may positively impact performance at an individual level since it may increase motivation and self-confidence. However, at the team level, an excessively high CSE may lead to an escalation of commitment, a lack of critical awareness and overconfidence, negatively

impacting team interactions and creative processes" (p. 175). This finding is intriguing because it is somewhat counterintuitive. It shows that, in some instances, increased self-efficacy can deter team innovativeness.

While it has been extensively studied, we would be remiss if we did not mention the areas of difficulty when studying and measuring self-efficacy and innovativeness. In Kleinsasser's (2014) analysis of TSE and the journals that examined it, the authors continuously highlight the need for a nuanced understanding of the concept. Regardless of the research modality, there is a clear need for an appropriate backdrop for our understanding of self-efficacy. As such, we operationalize innovation-related TSE similarly to that of Tschannen-Moran and Hoy (2001) in "A teacher's efficacy belief is a judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated . . ." (p. 783).

3. Conceptual framework

This study examines what factors make a difference in ITI and TTI. Based on the literature, we considered multiple factors. We grouped them into several categories according to their relationship (e.g. what occurs first) to teacher innovation: (1) innovation-related teacher preparedness, (2) innovation-related teacher PD, (3) teachers' professional practices, (4) teacher empowerment and (5) innovation-related TSE. We also believe TSE mediates other factors on teacher innovativeness. Figure 1 presents the conceptualized relationships between all the factors and the two outcomes.

Based on the conceptual framework, we developed two overarching hypotheses: first, we hypothesized that all five categories of factors have direct effects on teacher innovativeness. Second, to examine the mediation relationship, we followed the most recent literature (Memon *et al.*, 2018; Rungtusanatham *et al.*, 2014) and hypothesized that all the predictors also have indirect effects on teacher innovativeness mediated by TSE. To test these hypotheses, we asked two research questions:

RQ1. To what extent are these school factors directly associated with ITI and TTI?

RQ2. To what extent are the first four categories of school factors indirectly associated with ITI and TTI through TSE as a mediator?

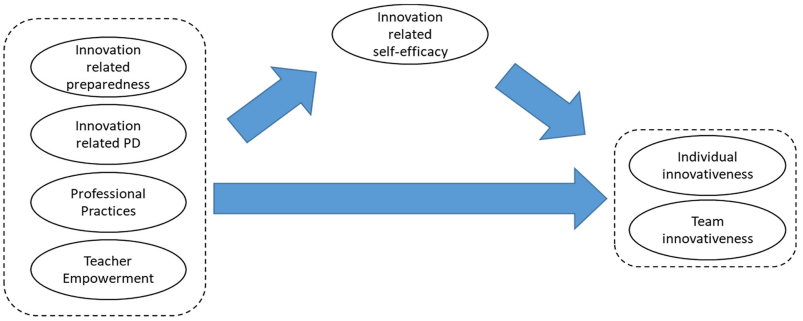


Figure 1.
Conceptual framework

Source(s): Figure by authors

4. Methods

4.1 Data source and sample

The data source is the 2018 TALIS US data. The samples include about 165 schools and 2,560 teachers.

4.2 Constructs and variables

Dependent variables. This study has two dependent variables: ITI and TTI. Both variables are latent based on four variables from the teacher data. For ITI, the question asked, "Thinking about your teaching in the target class, how often do **you** do the following", and teachers responded to four scenarios with a four-point Liker scale (1 = Never or almost never, 2 = Occasionally, 3 = Frequently, and 4 = Always). One scenario is "I present tasks for which there is no obvious solution." For the full description of the four variables, please see Appendix 1.

For TTI, the question asked, "Thinking about the **teachers in this school**, how strongly do you agree or disagree with the following statements?" Teachers responded to four scenarios with a four-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Agree, and 4 = Strongly agree). One scenario is, "Most teachers in this school strive to develop new ideas for teaching and learning." The wording "you" and "teachers in this school" tell us these two constructs are measured at individual and school levels, respectively. Moreover, the Like scale determined that larger values of the construct represent a more positive direction of innovativeness.

Independent variables. This study has five groups of teacher-level predictors: (a) two variables about innovation-related teacher preparedness (teaching CCS and use ICT for teaching), (b) three variables about innovation-related teacher PD (teaching CCS, ICT skills for teaching and focused on innovation in my teaching), (c) two latent variables about teachers' professional practices (exchange materials/engage in discussion and team teaching/peer observation), (d) two latent variables about teacher empowerment (teacher's classroom autonomy and teacher's participation in school decision) and (e) two latent variables measuring TSE with innovation (teacher's self-efficacy with helping students think critically, and teacher's self-efficacy with supporting students learning using technology). The variable descriptions and their descriptive statistics are presented in Appendix 1.

4.3 Analytical procedures

All the latent variables were validated by applying the confirmatory factor analysis (CFA). The relationship between constructs and variables was then examined using structural equation modeling (SEM), guided by our conceptual framework. We developed five sequential SEM models so that the five groups of factors were entered into SEM analysis sequentially according to their relationship with each of the two teacher innovativeness outcomes. The proportion of variance explained (PVC) for all five SEM models were calculated for the two outcomes. We developed our final mediation model using TSE as mediators based on the fifth SEM model.

To evaluate the measurement model and SEM models, we looked at the model fit indices, including chi-square, AIC/BIC, CFI/TLI, root mean square error of approximation (RMSEA) and standardized root mean squared residual (SRMR). We used SPSS 27.0 to prepare all the data. We used Mplus 8.6 to conduct the CFA and SEM analyses.

5. Findings

By applying CFA, we validated six latent constructs: the two PLC factors, the two empowerment factors and the two innovativeness measures. We then further developed five

SEM models and one final SEM model with mediation. All models presented good model fit indices (see Table 1). Here, we presented the results of the six SEM models.

5.1 Factors' direct effects on ITI

The results of the mediated SEM model are presented in Appendix 2. The results showed that four factors presented impressive direct and positive effects on ITI. Ranked by the magnitude of the regression coefficient, these effects are: (1) TSE in helping students with critical thinking ($\beta = 0.35$, *[0.30, 0.40]*), (2) TSE in supporting student learning with technology ($\beta = 0.26$, *[0.19, 0.32]*), (3) teacher professional practices-team teaching/peer observation ($\beta = 0.22$, *[0.15, 0.29]*) and (4) teacher preparedness in using ICT for teaching ($\beta = 0.10$, *[0.06, 0.14]*). These results suggest that a higher level of TSE, teacher professional practices–team teaching/peer observation and teacher preparedness in using ICT for teaching are associated with a higher level of ITI.

There is also one impressive direct but negative effect: PD that focuses on innovation in teaching ($\beta = -0.13$, *[−0.17, −0.08]*). This negative effect suggests that a higher level of teacher PD in innovation in teaching is linked to a lower level of ITI. Since the analysis is not causal but rather correlational, the negative effect may indicate that those teachers who perceived a lower level of innovativeness are in the process of their PD in innovation in teaching since they have the need. In comparison, teachers who perceived a higher level of innovativeness are not included in the PD process due to no need.

5.2 Factors' direct effects on TTI

The results showed that four factors presented impressive direct effects on TTI. According to the magnitude of the regression coefficient, these effects are: (1) school decision participation ($\beta = 0.31$, *[0.27, 0.36]*), (2) teacher professional practices–team teaching ($\beta = 0.13$, *[0.06, 0.20]*), (3) classroom autonomy ($\beta = 0.10$, *[0.06, 0.15]*), (4) preparedness–teaching CCS ($\beta = 0.09$, *[0.04, 0.14]*), (5) teacher professional practice–exchange materials/engage in discussion ($\beta = 0.08$, *[0.02, 0.15]*) and (6) preparedness–teaching CCS ($\beta = 0.07$, *[0.00, 0.13]*). These results suggest that higher levels of these six factors are associated with higher levels of ITI. Among the six positive effects, teachers' participation in school decisions presented a particularly strong effect, suggesting that distributed leadership and teacher buy-in in schools make a difference in TTI.

One impressive direct but negative effect is TSE in supporting student learning with technology ($\beta = -0.12$, *[−0.19, −0.05]*). The negative and positive effects of the other TSE in

Model	Chi-square	df	CFI/TLI	SRMR	RMSEA 95% CI
Team innovativeness	1.474	2	1.000/1.002	0.006	0.000 [0.000, 0.037]
Individual innovativeness	9.326	2	0.983/0.948	0.020	0.043 [0.018, 0.073]
2-factor PLC	17.653	8	0.983/0.968	0.021	0.022 [0.008, 0.036]
Classroom autonomy	12.285	5	0.988/0.975	0.025	0.027 [0.008, 0.047]
School participation	149.993	5	0.887/0.774	0.059	0.110 [0.095, 0.125]
SEM Model 1	70.764	31	0.978/0.969	0.029	0.024 [0.016, 0.031]
SEM Model 2	106.482	49	0.966/0.953	0.032	0.024 [0.018, 0.031]
SEM Model 3	290.401	131	0.933/0.918	0.049	0.025 [0.021, 0.029]
SEM Model 4	994.013	347	0.890/0.874	0.054	0.031 [0.028, 0.033]
SEM Model 5	1162.297	391	0.876/0.860	0.061	0.032 [0.029, 0.034]
Mediation model	1182.741	384	0.875/0.852	0.055	0.032 [0.030, 0.034]

Table 1.
Model fit indices

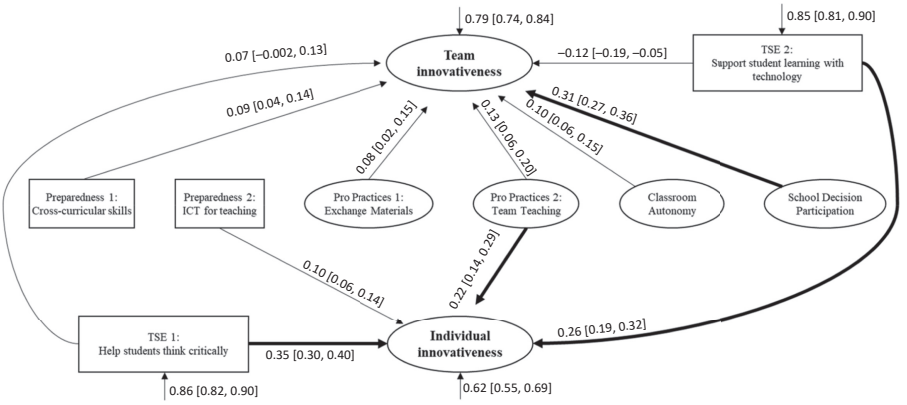
Source(s): Table by authors

helping students think critically suggest that TSE in technology is not associated with TTI, but TSE in critical thinking is.

We prepared one model diagram (Figure 2) to visualize these highlighted results to present the standardized direct effects. The variables shown in the ovals are latent, while the variables in the rectangles are observed variables (Kline, 2015).

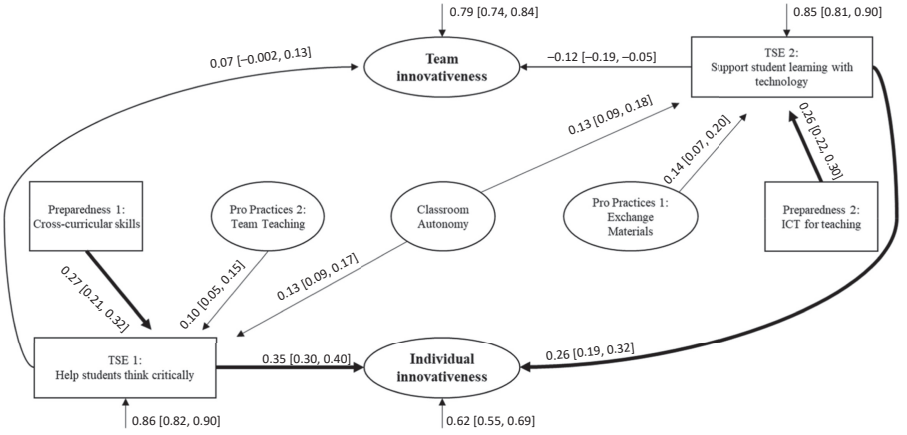
5.3 Factors' effects mediated by TSE-THINK

The results showed that five factors presented impressive indirect effects on ITI or TTI through the mediator TSE in critical thinking. According to the magnitude of effect on TSE (see Appendix 3), three impressive effects are highlighted here: (1) teacher preparedness in CCS (β = 0.27, *[0.21, 0.32]*), (2) classroom autonomy (β = 0.13, *[0.09, 0.17]*) and (3) professional practice–team (β = 0.10, *[0.05, 0.15]*). Please also see Figure 3 for a visual presentation. These positive effects suggest that higher levels of teacher preparedness in CCS, classroom autonomy and professional practice–team teaching are associated with higher levels of TSE in helping students think critically, positively affecting ITI.



Source(s): Figure by authors

Figure 2.
Direct paths and effects



Source(s): Figure by authors

Figure 3.
Indirect paths and effects

One impressive but negative effect is PD – focusing on innovation in teaching ($\beta = -0.09$, *[−0.14, −0.04]*). The negative effect suggests that a higher level of teacher PD on innovation in teaching is associated with lower levels of TSE in helping students think critically or vice versa. The negative effect may indicate that those teachers who perceived a lower level of self-efficacy in innovation are in the process of their PD in innovation in teaching since they have the need. In comparison, teachers who perceived a higher level of self-efficacy in innovation are not included in the PD process due to no need.

5.4 Factors' effects mediated by TSE-TCHN

The results also showed that three of the factors presented impressive indirect effects on either ITI or TTI through the mediator TSE in technology. According to the magnitude of effect on TSE (see Appendix 3), three impressive effects are highlighted here: (1) teacher preparedness in ICT ($\beta = 0.26$, *[0.22, 0.30]*), (2) professional practice–exchange ($\beta = 0.14$, *[0.07, 0.20]*) and (3) classroom autonomy ($\beta = 0.13$, *[0.09, 0.18]*). There are also two impressive negative effects on TSE-technology: (1) PD in ICT ($\beta = -0.16$, *[−0.25, −0.08]*) and (2) PD focusing on innovative teaching ($\beta = -0.09$, *[−0.14, −0.05]*). The negative effects suggest that participation in the two PD activities is associated with lower levels of TSE. It is possible that PD activities do not work well or teachers who participated are teachers who need PD because they perceived a lower level of TSE.

6. Discussions

In this section, we developed discussions around which factors make a difference in teacher innovativeness. We developed our discussions around the five groups of factors: (a) teacher preparedness, (b) teacher PD, (c) teacher professional practices, (d) teacher empowerment and (e) TSE.

6.1 To what extent does teacher preparedness make a difference in teacher innovativeness?

Our findings suggest that teacher preparedness does matter when teacher innovativeness is concerned. Blömeke *et al.* (2021) found that teachers' prior preparation in these skills is associated with school innovativeness. Our study went beyond that by revealing that different aspects of teacher preparedness are associated with teacher innovativeness at different levels. For example, it was found that using ICT for teaching is more directly related to ITI while teaching CCS is more directly associated with TTI. It makes sense that CCS, including creativity, critical thinking, learning to learn and problem-solving, are essential for collaboration between teachers teaching different subjects.

Beyond the direct effects, our study also found that the two aspects of teacher preparedness are indirectly associated with individual and TTI through one of the two TSE constructs. Teaching CCS was found to have a positive effect on both innovative outcomes through TSE – help students think critically. The situation for using ICT is double-edged. It indirectly and positively affects ITI through TSE – supporting student learning with technology. Still, it indirectly and negatively affects TTI through the same TSE construct.

Overall, the findings suggest that preparing teachers using ICT is more toward ITI, while preparing teachers with CCS is more helpful with TTI. These findings have important implications when school administrators and policymakers aim to promote teacher innovativeness at different levels.

6.2 To what extent does teacher PD make a difference in teacher innovativeness?

We examined three teacher PD variables' direct and indirect effects on teacher innovativeness. All the six direct effects except one are not impressive, with estimated effects either small or negative with a range between [−0.06, 0.06]. The one exception is the

effect of TPD-INV on ITI: $\beta = -0.13$, *[−0.17, −0.08]*. Through the two TSE mediators, the three teacher PD activities are not strongly and positively associated with teacher innovativeness. This does not mean teacher PD does not matter to teacher innovativeness, but rather, it could be due to the selection of the PD activities. In contrast, some other non-examined PD activities may potentially link to teacher innovativeness. This is an area requiring further investigation.

6.3 To what extent do teachers' professional practices make a difference in teacher innovativeness?

The findings suggest that the two examined teacher professional practices could make a difference in teacher innovativeness. Both team teaching and exchanging materials are directly associated with TTI, while team teaching is also positively associated with ITI. Indirectly, however, the two professional practices showed patterns. Team teaching had a positive effect on ITI through TSE – help students think critically. Exchanging materials had a positive effect on TSE – support student learning with technology, which had a negative effect on TTI and, overall, a negative indirect effect. Combining all the evidence, we tend to conclude that both professional practices make a difference with team teaching related to both but more with ITI while exchanging materials was only associated with TTI.

6.4 To what extent does teacher empowerment make a difference in teacher innovativeness?

Our findings suggest that classroom autonomy and school decision participation are directly and positively associated with TTI but not ITI. Indirectly, however, classroom autonomy is associated with both individual (positively) and TTI (negatively, due to the negative effect of TSE technology). Based on the evidence, we found that teacher empowerment does make a difference in teacher innovativeness, with school decision participation and classroom autonomy having a direct and positive effect on TTI while classroom autonomy having an indirect and positive effect on ITI.

6.5 To what extent does TSE make a difference in teacher innovativeness?

This study examined two TSE scales' effect on teacher innovativeness. The findings revealed that TSE in helping students think critically showed a positive effect on both ITI and TTI, while TSE in supporting student learning with technology had a positive effect on ITI but showed a negative effect on TTI. Overall, the findings are consistent with Park *et al.* (2021) study regarding the positive effect at the individual level and the negative effect at the team level.

6.6 Which factors make the most difference in teacher innovativeness?

We found that all factors could positively affect teacher innovativeness at the individual teacher level, except for the two PD factors. Directly, the two TSE constructs are the two strongest and direct predictors of teacher innovativeness, followed by one professional practices factor (team teaching) and one preparedness factor (ICT for teaching).

Indirectly, the other preparedness factor CC) presented the strongest mediating effect through TSE in helping students think critically, which is followed by one teacher empowerment factor (classroom autonomy) and one professional practices factor (team teaching). At the same time, teacher preparedness factor (ICT for teaching) presented the strongest mediating effect through TSE in Supporting students learning with technology, followed by professional practices factor (exchange materials) and classroom autonomy.

At the team level, we also found that all factors could make a difference, either positively or negatively, in teacher innovativeness, except the two PD factors. Directly, one teacher empowerment factor (school decision participation) presented the strongest positive effect,

which was followed by professional practices factor (team teaching), classroom autonomy, preparedness in CCS, and the other professional practices factor (exchange materials). The two TSE constructs did not show as strong effects as they did at the individual level. Instead, on average, TSE in helping students think critically presented a smaller positive effect than all the above factors, which could be as small as negative (see the confidence interval). And TSE in supporting students learning with technology presented a negative effect.

Indirectly, all the factors we discussed above that affected ITI also presented a mediating effect on TTI through the two TSE constructs. Its strength and direction, however, were greatly impacted by the direct effect of the two TSE constructs, as we discussed above. In other words, all the indirect effects on TTI are not very promising due to TSE's small effect.

7. Conclusions and implications

We drew four conclusions based on the results and the above discussions. First, for ITI, four factors (TSE in helping students think critically, TSE in supporting student learning with technology, professional practices – team teaching and preparedness – ICT for teaching) are positive predictors with direct effects. In contrast, innovation-related PD factors and teacher empowerment factors are not directly associated with ITI. This finding allows educators to better adjust how we train and support teachers. If the goal for a teacher is to increase their ITI, then we can see that sending them to PD training or telling them that they are empowered to make their own choices is not enough. Teachers need to be efficacious in helping their students think critically and how technology is used in their lessons. To do this, we find, similarly to Tang (2021), that professional practices like team teaching and ICT preparedness are critical for ITI.

Second, TTI, six factors (school decision participation, professional practice – team teaching, classroom autonomy and preparedness – CCS, professional practices–change materials and TSE in helping students think critically) are positive predictors with direct effects, while TSE in supporting student learning with technology is a negative predictor with direct effect. Again, innovation-related PD factors are not directly associated with ITI. We see here that developing TTI encompasses a broader range of predictors. This allows teachers to build upon the preexisting strengths within their contexts readily. Similar to the findings of (O'Shea, 2021), we see that TTI is tied to empowerment through autonomy and school decision participation. Though technology can be an incredible lever for student learning, simply having self-efficacy with technology does not directly support ITI.

Third, three factors (preparedness – CCS, classroom autonomy and professional practices – team teaching) are indirectly and positively associated with ITI through TSE in helping students think critically, and the other three factors (classroom autonomy, professional practices – exchange materials and preparedness – ICT for teaching) are indirectly and positively associated with ITI through TSE in supporting student learning with technology. It is noted that although classroom autonomy did not show a direct effect on ITI, it presented a significant indirect effect through both TSE mediators. Innovation-related PD factors are not indirectly associated with ITI.

Lastly, three factors (preparedness – CCS, classroom autonomy and professional practices – team teaching) are indirectly and positively associated with TTI through TSE in helping students think critically, and the other three factors (classroom autonomy, professional practices – exchange materials and preparedness – ICT for teaching) are indirectly and negatively associated with TTI through TSE in supporting student learning with technology. Again, innovation-related PD factors are not indirectly associated with ITI.

The findings of the study overall demonstrate the importance of other stakeholders beyond school buildings. Whether thinking of seminal works and understandings of the importance of funds of knowledge held in the community (Moll *et al.*, 1992) or considering

whose culture has capital in the decision-making of a school (Yosso, 2005). The work to develop the voice of stakeholders includes the community, but it also includes educator preparation programs, accrediting bodies and PD organizations. Educator preparation programs should examine the findings to help guide their curriculum development. Since school decision participation and TSE were the two largest predictors in the study, it would make sense for preparation programs to introduce the theoretical components and model the behavior in their settings. These programs could model these behaviors for their students to help them understand how to incorporate them into the field.

The findings of this study echo the work of Nguyen *et al.* (2019) and Nguyen and Ng (2020) in that enhanced team innovation in an educational setting requires a collaborative culture for the implementation and diffusion of innovations. For educators to develop practices of innovativeness, they need the support and self-efficacy to do so. The collaboration required for team teaching and peer observation is also critical to this work, as previously examined by Nguyen *et al.* (2021). Similar to their findings that teacher collaboration was more important to innovation than teacher autonomy, we found that the group item of school decision participation was more directly significant than classroom autonomy for TTI. This demonstrates the integral need for this work to be done. We can no longer wait and hope educators will continue to step up and make adjustments on their own time to address relevance gaps between the current curriculum and what students may need in their futures. To genuinely address equity issues, schools can no longer be content with providing content that only supports the learning of a chosen few (McLeod and Shareski, 2018). Schools and school systems need to support collaboration and enhance self-efficacy in their teachers through continued PD and support to enhance individual and TTI.

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Appendix 1

Table A1. Description and descriptive statistics of variables

Variable name	Variable description	Coding	Descriptive Statistics
Teacher individual innovativeness (Cognitive activation)			
42. Thinking about your teaching in the target class, how often do you do the following			
TT3G42E	I present tasks for which there is no obvious solution	1 = Never or almost never	M = 2.09 STD = 0.88
TT3G42F	I give tasks that require students to think critically	2 = Occasionally	M = 2.96 STD = 0.65
TT3G42G	I have students work in small groups to come up with a joint solution to a problem or task	3 = Frequently	M = 2.74 STD = 0.77
TT3G42H	I ask students to decide on their own procedures for solving complex tasks	4 = Always	M = 2.45 STD = 0.8
Team innovativeness			
32. Thinking about the teachers in this school, how strongly do you agree or disagree with the following statements?			
TT3G32A	Most teachers in this school strive to develop new ideas for teaching and learning	1 = Strongly disagree, 2 = Disagree 3 = Agree	M = 3.04 STD = 0.7
TT3G32B	Most teachers in this school are open to change	4 = Strongly agree	M = 2.75 STD = 0.7
TT3G32C	Most teachers in this school search for new ways to solve problems		M = 2.88 STD = 0.69
TT3G32D	Most teachers in this school provide practical support to each other for the application of new ideas		M = 3.02 STD = 0.7
Innovation related teacher preparedness			
6. and to what extent did you feel prepared for each element in your teaching?			
Teacher preparedness for cross-curricular skills (TT3G06G2)	g) Teaching cross-curricular skills (e.g. creativity, critical thinking and problem solving)	1 = not at all 2 = somewhat 3 = well	M = 2.78 STD = 0.87
Teacher preparedness for use of ICT (TT3G06H2)	h) Use of ICT (information and communication technology) for teaching	4 = very well	M = 2.43 STD = 0.96

(*continued*)

Variable name	Variable description	Coding	Descriptive Statistics
Related professional development			
23. Were any of the topics listed below included in your professional development activities during the last 12 months			
Teacher professional development in ICT (TT3G23E)	Areas prof.dev. ICT skills for teaching	0 = no 1 = yes	M = 0.64 STD = 0.48
Teacher professional development in cross-curricular skills (TT3G23K)	Areas prof.dev. Teaching cross-curricular skills		M = 0.6 STD = 0.49
26. Thinking of the professional development activity that had the greatest positive impact on your teaching during the last 12 months, did it have any of the following characteristics			
Teacher professional development on innovation (TT3G26L)	Focused on innovation in my teaching	0 = no 1 = yes	M = 0.71 STD = 0.45
Teacher professional practices			
33. On average, how often do you do the following in this school?			
Exchange materials/Engage in discussion		1 = Never	
TT3G33A	How often you do teach jointly as a team in the same class	2 = Once a year or less 3 = 2–4 times a year	M = 2.55 STD = 2.05
TT3G33B	How often you do observe other teachers classes and provide feedback	4 = 5–10 times a year 5 = 1–3 times a month 6 = Once a week or more	M = 2.09 STD = 1.28
TT3G33C	How often you do engage in joint activities		M = 2.22 STD = 1.43
TT3G33H	How often you do take part in collaborative professional learning		M = 3.91 STD = 1.54
Team teaching/Peer observation			
TT3G33D	How often you do exchange teaching materials with colleagues		M = 4.39 STD = 1.65
TT3G33E	How often you do engage in discussions about the learning development		M = 4.79 STD = 1.41
TT3G33F	How often you do work with other teachers in this school		M = 4.01 STD = 1.75
TT3G33G	How often you do attend team conferences		M = 3.79 STD = 1.88
Classroom autonomy			
40. How strongly do you agree or disagree that you have control over the following areas of your planning and teaching in this target class			
TT3G40A	Determining course content	1 = Strongly disagree, 2 = Disagree	M = 3.08 STD = 0.97
TT3G40B	Selecting teaching methods	3 = Agree 4 = Strongly agree	M = 3.53 STD = 0.68
TT3G40C	Assessing students learning		M = 3.41 STD = 0.71
TT3G40D	Disciplining students		M = 3.2 STD = 0.79
TT3G40E	Determ. amount of homework to be assigned		M = 3.5 STD = 0.7

(*continued*)

Table A1.

Variable name	Variable description	Coding	Descriptive Statistics
School decision participation			
48: How strongly do you agree or disagree with these statements, as applied to this school?			
TT3G48A	Sch provides staff w. opp. to actively participate in sch decisions	1 = Strongly disagree, 2 = Disagree 3 = Agree 4 = Strongly agree	M = 3.08 STD = 0.97
TT3G48B	Sch provide parents/guardians w. opportunities active part in school decisions		M = 3.53 STD = 0.68
TT3G48C	Sch provide studs w. opp. to actively participate in sch decisions		M = 3.41 STD = 0.71
TT3G48D	Sch has a culture of shared responsibility for school issues		M = 3.2 STD = 0.79
TT3G48E	There is a collaborative sch culture characterized by mutual support		M = 3.5 STD = 0.7
Innovation-related TSE			
34. In your teaching, to what extent can you do the following?			
TSE in students critical thinking (TT3G34G)	Help students think critically	1 = not at all 2 = to some extent 3 = quite a bit 4 = a lot	M = 3.16 STD = 0.71
TSE in students use technology (TT3G34M)	Support student learning via the use of digital technology		M = 3.12 STD = 0.86

Table A1. **Source(s):** Table by authors

Appendix 2

Table A2. Direct, indirect and total effects on individual and team innovativeness

Mediator	Predictor	Individual innovativeness β	S.E.	t	*p*	95%CI	Team innovativeness β	S.E.	t	*p*	95%CI
TSE-THNK	TP-CCS	0.09	0.01	6.39	0.00	[0.06, 0.12]	0.02	0.01	1.66	0.10	[0.00, 0.04]
TSE-TCHN	TP-CCS	−0.01	0.01	−1.99	0.05	[−0.03, 0]	0.01	0.00	1.55	0.12	[0.00, 0.01]
Direct	TP-CCS	0.04	0.02	1.69	0.09	[−0.01, 0.08]	0.09	0.02	3.70	0.00	[0.04, 0.14]
	Total	0.12	0.03	4.69	0.00	[0.07, 0.16]	0.11	0.04	3.28	0.00	[0.05, 0.18]
TSE-THNK	TP-ICT	0.00	0.01	0.55	0.58	[−0.01, 0.02]	0.00	0.00	0.60	0.55	[0.00, 0.00]
TSE-TCHN	TP-ICT	0.07	0.01	6.08	0.00	[0.05, 0.09]	−0.03	0.01	−2.88	0.00	[−0.05, −0.01]
Direct	TP-ICT	0.10	0.02	4.61	0.00	[0.06, 0.14]	0.00	0.02	0.21	0.84	[−0.03, 0.04]
	Total	0.17	0.02	7.64	0.00	[0.13, 0.22]	−0.03	0.02	−1.19	0.24	[−0.07, 0.02]
TSE-THNK	TPD-ICT	−0.01	0.01	−1.34	0.18	[−0.03, 0.01]	0.00	0.00	−0.87	0.39	[−0.01, 0.00]
TSE-TCHN	TPD-ICT	−0.04	0.02	−2.83	0.01	[−0.07, −0.01]	0.02	0.01	1.87	0.06	[0.00, 0.04]
Direct	TPD-ICT	−0.03	0.04	−0.93	0.35	[−0.10, 0.04]	0.03	0.01	2.36	0.02	[0.01, 0.06]
	Total	−0.09	0.05	−1.64	0.10	[−0.19, 0.02]	0.05	0.02	3.21	0.00	[0.02, 0.08]
TSE-THNK	TPD-CCS	−0.01	0.01	−0.43	0.67	[−0.03, 0.02]	0.00	0.00	−0.45	0.65	[−0.01, 0.00]
TSE-TCHN	TPD-CCS	0.01	0.01	1.02	0.31	[−0.01, 0.02]	0.00	0.00	−0.91	0.37	[−0.01, 0.00]
Direct	TPD-CCS	−0.01	0.02	−0.63	0.53	[−0.04, 0.02]	0.02	0.02	0.70	0.49	[−0.03, 0.06]
	Total	−0.01	0.03	−0.36	0.72	[−0.07, 0.05]	0.01	0.02	0.55	0.58	[−0.03, 0.05]
TSE-THNK	TPD-INV	−0.03	0.01	−3.18	0.00	[−0.05, −0.01]	−0.01	0.00	−1.35	0.18	[−0.01, 0.00]
TSE-TCHN	TPD-INV	−0.02	0.01	−3.03	0.00	[−0.04, −0.01]	0.01	0.01	2.23	0.03	[0.00, 0.02]
Direct	TPD-INV	−0.13	0.02	−5.60	0.00	[−0.17, −0.08]	−0.04	0.01	−2.55	0.01	[−0.06, −0.01]
	Total	−0.18	0.03	−5.26	0.00	[−0.25, −0.11]	−0.03	0.02	−2.05	0.04	[−0.06, 0.00]
TSE-THNK	TPP-TEAM	0.03	0.01	3.36	0.00	[0.01, 0.05]	0.01	0.00	1.63	0.10	[0.00, 0.01]
TSE-TCHN	TPP-TEAM	0.02	0.01	2.18	0.03	[0, 0.03]	−0.01	0.00	−1.91	0.06	[−0.02, 0.00]
Direct	TPP-TEAM	0.22	0.04	5.93	0.00	[0.15, 0.29]	0.13	0.04	3.78	0.00	[0.06, 0.20]
	Total	0.27	0.04	6.99	0.00	[0.19, 0.34]	0.13	0.04	3.65	0.00	[0.06, 0.20]
TSE-THNK	TPP-EXCH	0.03	0.01	3.10	0.00	[0.01, 0.04]	0.01	0.00	1.56	0.12	[0.00, 0.01]
TSE-TCHN	TPP-EXCH	0.04	0.01	3.04	0.00	[0.01, 0.06]	−0.02	0.01	−2.10	0.04	[−0.03, 0.00]
Direct	TPP-EXCH	−0.01	0.03	−0.36	0.72	[−0.06, 0.04]	0.08	0.03	2.43	0.02	[0.02, 0.15]
	Total	0.05	0.03	1.47	0.14	[−0.02, 0.12]	0.07	0.04	2.00	0.05	[0.00, 0.14]
TSE-THNK	CLASSAUT	0.04	0.01	5.03	0.00	[0.03, 0.06]	0.01	0.01	1.64	0.10	[0.00, 0.02]
TSE-TCHN	CLASSAUT	0.03	0.01	3.89	0.00	[0.02, 0.05]	−0.02	0.01	−2.38	0.02	[−0.03, 0.00]
Direct	CLASSAUT	−0.01	0.02	−0.61	0.54	[−0.05, 0.03]	0.10	0.02	4.65	0.00	[0.06, 0.15]

(*continued*)

Table A2.

Mediator	Predictor	Individual innovativeness					Team innovativeness				
		β	S.E.	t	*p*	95%CI	β	S.E.	t	*p*	95%CI
	Total	0.07	0.03	2.57	0.01	[0.02, 0.12]	0.10	0.02	4.37	0.00	[0.05, 0.14]
TSE-THNK	PARTICPT	0.02	0.01	3.20	0.00	[0.01, 0.03]	0.00	0.00	1.51	0.13	[0.00, 0.01]
TSE-TCHN	PARTICPT	0.00	0.01	−0.42	0.68	[−0.02, 0.01]	0.00	0.00	0.40	0.69	[−0.01, 0.01]
Direct	PARTICPT	−0.02	0.02	−0.69	0.49	[−0.06, 0.03]	0.31	0.02	14.15	0.00	[0.27, 0.36]
	Total	0.00	0.03	0.04	0.97	[−0.05, 0.06]	0.32	0.02	14.59	0.00	[0.28, 0.36]

Source(s): Table by authors

Appendix 3

Predictor	TSE-THNK β	S.E.	t	*p*	95%CI	TSE-TCHN β	S.E.	t	*p*	95%CI
TPP-TEAM	0.10	0.03	3.65	0.00	[0.05, 0.15]	0.07	0.03	2.23	0.03	[0.01, 0.12]
TPP-EXCH	0.07	0.02	3.04	0.00	[0.03, 0.12]	0.14	0.03	4.34	0.00	[0.07, 0.20]
CLASSAUT	0.13	0.02	6.36	0.00	[0.09, 0.17]	0.13	0.02	6.09	0.00	[0.09, 0.18]
PARTICPT	0.06	0.02	3.22	0.00	[0.02, 0.09]	−0.01	0.03	−0.42	0.67	[−0.06, 0.04]
TP-CCS	0.27	0.03	9.75	0.00	[0.21, 0.32]	−0.05	0.02	−2.31	0.02	[−0.10, −0.01]
TP-ICT	0.01	0.02	0.56	0.58	[−0.03, 0.05]	0.26	0.02	13.57	0.00	[0.22, 0.30]
TPD-ICT	−0.04	0.03	−1.35	0.18	[−0.1, 0.02]	−0.16	0.04	−3.65	0.00	[−0.25, −0.08]
TPD-CCS	−0.02	0.04	−0.42	0.68	[−0.08, 0.06]	0.02	0.02	1.07	0.28	[−0.02, 0.06]
TPD-INV	−0.09	0.03	−3.65	0.00	[−0.14, −0.04]	−0.09	0.02	−4.21	0.00	[−0.14, −0.05]

Source(s): Table by authors

Table A3.
Direct effects on TSE

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