



How school support and teacher perception affect teachers' technology integration: A multilevel mediation model analysis

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Abstract

Literature indicates that teachers' technology integration is affected by internal (individual feeling) and external (support from schools) factors. How the two levels of factors affect continuous technology integration remains unclear. Drawing upon the organizational support theory, this study thus proposes a multilevel model to examine how factors at two levels—teacher and school—account for teachers' technology integration. In the model, teachers' technology integration is a teacher-level variable, while school support at the school level, refers to how well the school supports teachers. The model specifically investigates the serial mediating roles of teachers' perceived school support and ICT self-efficacy in the relationship between school support and teachers' technology integration. Large-scale data (297 schools and 8041 teachers) was collected for analysis. The multilevel mediation model was constructed and analyzed using a multilevel structural equation modeling (MSEM) approach. Key results from the analysis illuminate that school support can only impact teachers' technology integration when teachers' perceived school support acts as a mediator. Teachers' ICT self-efficacy also plays a partial mediation role between teachers' perceived school support and their technology integration. These findings validate the proposed model. They highlight teachers' unarticulated need for a supportive school environment and the crucial role of teachers' perceptions in translating school support into technology integration practices. In doing so, we make a contribution to the methodology for developing effective school support and cultivating appropriate teacher perception for teachers' technology integration that also extends to creating a supportive school environment by considering both internal and external factors.

Keywords K-12 education · In-service teachers · School support · ICT self-efficacy · Technology integration · Multilevel structural equation model

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1 Introduction

The rapid advancement of technologies continues to challenge teachers' technology integration in school systems. Teachers are expected to teach with emerging technologies and embrace new pedagogies (Qu et al., 2023). However, teachers encounter various barriers in their technology integration, including insufficient school support, mental unwillingness, and personal deficiencies (Ertmer, 1999; Johnson & Tawfik, 2022; Kopcha, 2012; Tsai & Chai, 2012; Xie et al., 2023). To overcome these barriers, teachers require diverse kinds of support from schools (Atman Uslu & Usluel, 2019; Cai & Tang, 2021; Drossel et al., 2017; Hsu & Kuan, 2013; Konstantinidou & Scherer, 2022). School-level support in terms of technology and policy underpins teachers' successful technology integration (Vongkulluksn et al., 2018; Wu et al., 2019). However, negative effects of school support on teachers' technology integration have also been found (Han et al., 2018; Konstantinidou & Scherer, 2022). The mixed findings imply the existence of potential factors between school support and teachers' technology integration. To address the gap, this study modelled the cross-level association between school support and teachers' technology integration to explore possible key factors between them.

Several theoretical frameworks have been employed to comprehend the multifaceted nature of educational technology integration. A review conducted by Sackstein et al. (2022) consolidated multiple theories into four categories: technology acceptance/adoption/use theories and models (e.g. Technology Acceptance Model); social theories (e.g. Activity Theory); structuration theories (e.g. Adaptive Structuration Theory); education and technology models (e.g. Hierarchical Model of Technology Adoption). The researchers inferred that technology acceptance/adoption/use theories and models are preferred for studies like this. It entails embracing a positivist paradigm to explore the prediction of teachers' technology use. For teachers, previous attempts with traditional models like Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, Theory of Reasoned Action, and TPB (Theory of Planned Behavior) interpreted their technology integration relying on individual factors (Khlaif, 2018; Sackstein et al., 2022; Teo et al., 2016; Zhao et al., 2020). Subsequent research recognized the contribution of external factors to teachers' technology integration and highlighted the role of school support (Fernández-Batanero et al., 2022; Turgut & Aslan, 2021). Concurrently, comprehensive theoretical perspectives combining both external and individual factors have become increasingly prevalent in statistical modeling.

Numerous studies, for instance, applied the Barrier to Technology Integration model, which categorizes teachers' external and internal barriers in their technology integration (Burçin Hamutoğlu & Basarmak, 2020; Ertmer, 1999; Makki et al., 2018; Vongkulluksn et al., 2018; Xie et al., 2023). According to their conclusions, teachers need school support to surmount external barriers and cultivate positive perceptions to overcome internal barriers. The relationships between school support and teachers' perceptions have garnered attention as well (Burçin Hamutoğlu & Basarmak, 2020; Vongkulluksn et al., 2018). Beyond fostering

positive perception, teachers' need for well-being and motivation was highlighted by other theoretical perspectives, like the Expectancy-Value theory and Self-Determination theory in current research (Back et al., 2021; Cheng et al., 2020; Chiu, 2022; Sipilä, 2011). The external school environment was seen as a foundational element in supporting teachers' well-being in their technology integration (Chiu, 2022). In summary, this study built upon prior findings from diverse theoretical perspectives to explore teachers' technology integration at both organizational and individual levels. The OST (Organizational Support Theory) was applied to build the relationships between school support and teachers' perceptions, well-being, as well as technology integration.

OST proposed by Eisenberger et al. (1986) posits that employees form a general perception concerning to what extent the organization values their contributions and cares about their well-being. Additionally, there were positive connections between employees' perceived organizational support and their performance in the organization (Kurtessis et al., 2017; Zhao et al., 2020). According to OST, teachers' perceived school support also plays a pivotal role in their ICT integration process. Teachers need sufficient support instead of being simply provided with resources or rules. Accordingly, this study assumes that both school support and teachers' perceived school support positively connect to teachers' technology integration. Besides, a positive connection has been found between school support and teachers' perceived school support (Vongkulluksn et al., 2018). To the best of our knowledge, this study is the few initiated attempts to apply the theory in studying teachers' technology integration from an "organizational-individual" perspective.

Furthermore, this study introduced teachers' ICT self-efficacy as a mediator between teachers' perceived school support and their technology integration. To augment teachers' meaningful technology integration, it is imperative to consider teachers' well-being and motivation (Chiu, 2022). Teachers' ICT self-efficacy was recognized as a critical motivator driving teachers' technology integration (Moreira-Fontán et al., 2019; Yu et al., 2021). Teachers' ICT self-efficacy was discovered as a mediator between teachers' perceived school support and their technology integration (Dong et al., 2020; Wang & Zhao, 2021). Considering the instrumental role played by teachers' ICT self-efficacy, this study incorporated the factor to shed light on the mechanisms behind teachers' technology integration. With two serial mediators, this study provides a more intricate comprehension of teachers' technology integration, concerning teachers' initiatives and autonomy.

Drawing from the foregoing, a multilevel model was constructed and analyzed with a multilevel structural equation modeling (MSEM) method. The model established intricate associations among school support, teachers' perceived school support, teachers' ICT self-efficacy, and teachers' technology integration. Large-scale data from 297 schools and 8041 teachers were collected. On the one hand, the model aligned with previous insights regarding the link between school support and teachers' technology integration. On the other hand, the model offered strength over previous research by incorporating multilevel factors and serial mediators based on a relatively novel theoretical perspective. Given the push towards educational advancements through technology, it is of paramount importance to explore how schools can more effectively promote teachers' technology integration (Wang

& Zhao, 2021). Evidence-based suggestions were provided based on the multilevel mediation model. These suggestions relate to eliminating obstacles between school support and teachers' technology integration.

2 Theoretical framework

2.1 Organizational support theory

Organizational Support Theory, as conceptualized by Eisenberger et al. (1986), elucidates the influence of employees' perception concerning the degree to which organizations care about their contributions and well-being. Various elements of organizational support, such as resources and policy, profoundly impact employees' perceptions (Rhoades & Eisenberger, 2002). Additionally, employees perceived organizational support has been empirically associated with enhancements in employees' subjective well-being and performance (Kurtessis et al., 2017; Meira & Hancer, 2021). However, it remains a relatively unexplored field that applies OST theory to examine teachers' technology integration in schools.

Through the lens of OST, school support as a form of organizational support should be an influential factor to teachers' (employees') perceived school support. Teachers' perceived school support, in turn, significantly impacts their technology integration. Fundamentally, OST provides insight into the mechanism underlying the impact of school support on teachers' technology integration, considering teachers' perceptions and well-being. School support has been found to predict teachers' perceptions of it (Vongkulluksn et al., 2018). In alignment with OST theory, teachers perceived school support also correlated to their innovativeness and intention to use technology (Zhao et al., 2020). Furthermore, the relationships between school support and teachers' technology integration could be mediated by teachers' perceptions (Liu et al., 2017). These pieces of evidence indicate the untapped potential of applying OST in studying teachers' technology integration in schools. Therefore, this research explored the relationships between school support and teachers' technology integration from the perspective of OST. Potential mediators were also unearthed.

2.2 From school support to teachers' technology integration

2.2.1 Mediation role of teachers' perceived school support

This study designated school-level support for teachers' technology integration as school support. Categorized by Vongkulluksn et al. (2018), teachers mainly receive support as technical resources and administrative policies from schools. Teachers' successful technology integration first requires the accessibility of technology and administration support to overcome external barriers. Schools' technical infrastructure supports teachers' practice with hardware and software (Drossel et al., 2017), classroom space (Liu et al., 2017), and ample bandwidth (Wu et al., 2022). Research

has indicated that teachers' primary impediment to incorporating ICT is the inadequacy or paucity of the ICT infrastructure (Gil-Flores et al., 2017). Schools also provide policies to ensure teachers' time for practice (Merga et al., 2021), application arrangements (Wu et al., 2019), and training programs (Li et al., 2019). Support from schools' administration has been regarded as indispensable to teachers' technology integration (Francom, 2020). Thus, this study proposed the hypothesis that school support may impact teachers' technology integration (H1).

Apart from external barriers, teachers also encounter internal barriers in their technology integration. To illustrate the individual factors that create impediments to school support, teachers' perceptions and beliefs were analyzed. As an integral aspect of teachers' perceptions, teachers' perceived school support shapes their ideas about teaching and learning. Teachers' perceived school support has emerged as a potent factor that affects teachers' technology integration (H6) (Jung et al., 2019; Spiteri & Chang Rundgren, 2020). Additionally, evidence suggests that a gap exists between school support and teachers' integration. The implementation of school support was impacted by teachers' internalization of it (Inan & Lowther, 2010; Karaca et al., 2013). In other words, the adequacy of school support is partly determined by teachers' perceived school support (Xie et al., 2023). Teachers' perceived school support can function as a mediator between school support and teachers' technology integration (Vongkulluksn et al., 2018) (H3, H6).

2.2.2 Mediation role of teachers' ICT self-efficacy

Contemporary research revealed that teachers' motivation should be underlined by schools to promote educational technology initiatives (Chiu, 2022). Teachers' self-efficacy can reflect their motivation (Barni et al., 2019). It is important to study the role of self-efficacy in the implementation of school support for teachers' sustained professional development (Chang et al., 2010). From the perspective of OST, employees' self-efficacy has been identified as a mediator between their perceived organizational support and perceived ability (Sürücü et al., 2022). As a sense of self-efficacy, teachers' ICT self-efficacy was regarded in this study.

Teachers' ICT self-efficacy was defined as the confidence teachers hold in their competence to utilize ICT for teaching and learning (Moreira-Fontán et al., 2019). Self-efficacy is viewed as a primary indicator of the individual factor in Bandura's social cognitive theory, which indicates there is a reciprocal determinism between the individual and the environment. According to the theory, a supportive environment influences individuals' self-efficacy (Bandura, 2002). In the context of education, when schools provide teachers with adequate support, like providing the infrastructure necessary for them to conduct curriculum or granting teachers' autonomy in making decisions on their teaching practices, teachers' self-efficacy could be enhanced (H4) (Jentsch et al., 2023; Usluel, 2007). Moreover, previous studies have demonstrated that teachers possessing higher ICT self-efficacy are more inclined to perceive themselves as capable of executing effective technology integration (H5) (Cai & Tang, 2021; Drossel et al., 2017; Hatlevik, 2017). In addition, previous studies also discovered teachers' ICT self-efficacy partly mediates teachers' perceived school support and teachers' technology integration (H4, H5, H6) (Dong et al.,

2020; Wang & Zhao, 2021). Hence, we selected teachers' ICT self-efficacy as a potential mediating variable.

2.3 The present study

The present study proposed a multilevel conceptual model, based on OST, to understand the impact of school- and teacher-level factors on teachers' technology integration. More specifically, the school level concerns how schools support teachers; and the teacher level concerns how teachers perceive the support and their ICT self-efficacy. This model accommodates both individual (i.e., teachers' perceived school support) and external (i.e., school support) factors, thereby distinguishing it from the majority of related studies only focusing on either teachers' individual beliefs (Dong et al., 2020; Wang & Zhao, 2021) or school resource (Wu et al., 2019, 2022). It delineates how the two kinds of factors relate and affect the teacher technology integration process with a relatively novel theoretical perspective. This research also attempts to elucidate the mixed findings yielded by previous research. For instance, while most research has concluded that school support predicts teachers' perceived school support, Han et al. (2018) discovered a negative correlation between teachers' perceived administration support—a component of perceived school support—and teachers' technology usage. Konstantinidou and Scherer (2022) likewise found that the availability of computer resources at school did not correlate to teachers' use of technology.

Within this model, the external factor is school support, the individual factors are perceived school support and ICT self-efficacy. The individual factors are serial mediators between external factors and teachers' technology integration. To complete the model, an additional hypothesis was incorporated into the conceptual model (Fig. 1): a positive relationship is presumed to exist between school support and teachers' ICT self-efficacy. It has been suggested that school support can create

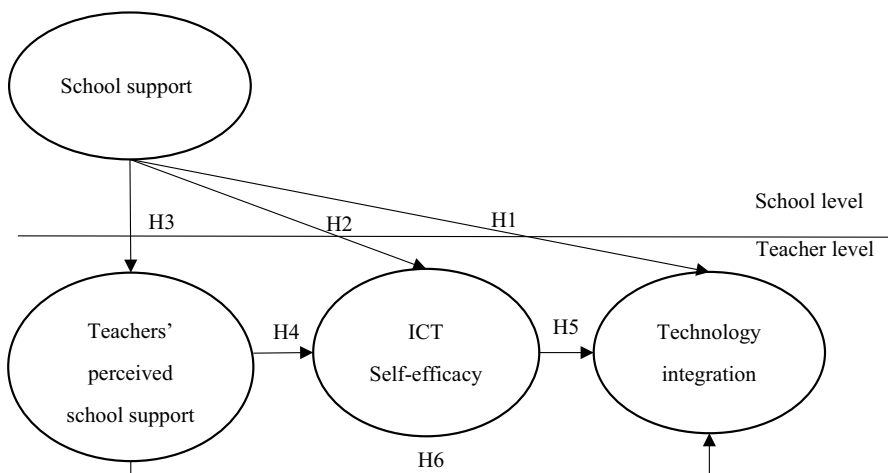


Fig. 1 The conceptual multilevel mediation model constructed in the current study

a conducive climate, which in turn increases teachers' self-efficacy (H2) (Zhang et al., 2023). In summary, this study aims to evaluate the multilevel model. Two research questions were proposed:

RQ1: How does the school-level effect of school support on teachers' technology integration get mediated through individual factors (teachers' perceived school support and ICT self-efficacy)?

RQ2: How does teachers' ICT self-efficacy mediate the relationships between teachers' perceived school support and their technology integration at the teacher level?

3 Method

3.1 Data collection

The sampling criteria of this study were designed to capture a representative and diverse snapshot of K-12 schools from Southern China, ensuring a broad spectrum of economic, educational, and technological contexts is reflected. By selecting 349 schools from 21 prefecture-level cities, spanning both rural and urban areas, as well as different types of K-12 schools, the study aimed to encapsulate the realities of different-level technology integration within the educational sector. 349 administrators and 9,077 in-service teachers were gathered to join this study and provide large-size data. An administrator was invited for each of the schools. Among the investigated teachers, 46.6% of them were from urban schools (4392), and 53.4% of them were from rural schools (3749). Besides, there were 4639 primary school teachers (57.7%), 3096 junior high school teachers (38.5%) and 306 senior high school teachers (3.8%). The sources of teachers were set to ensure that the collected data would be sufficiently representative of the area and the subjects of this study.

Administrators and teachers were asked to complete their corresponding questionnaire online. Some of the administrators and teachers did not complete the questionnaire and their records were removed. To avoid inconsequence, schools with teachers less than 3 were also removed. The final samples were from 8041 teachers and 297 schools. The mean cluster size was 27.07.

3.2 Instrument

3.2.1 School administrator questionnaire

The school administrator questionnaire comprises five items, each measuring school support on a 5-point Likert scale (1 strongly disagree, 5 strongly agree). The scale is part of a large-scale questionnaire designed following the method of Wu et al. (2019). The questionnaire was first examined by six experts from (1) ICT research centers (2) provincial and local education administrative departments (3) K-12 schools. Second, after rounds of discussion, pilot tests collected responses from

school administrators to learn schools' condition of technology resources and policy. Second, after rounds of discussion, the pilot test collected responses from school administrators to learn the schools' condition and design accurate questionnaire items. Considering the administrator's perspective, the questionnaire applied in this study investigated demographic information and school support. The demographic information includes school location and school type. It also surveyed the education experience of school administrators. School support as a factor is related to the schools' evaluation policy and technology devices provided for teachers. Detailed descriptions of these items are depicted in Appendix A.

3.2.2 Teacher questionnaire

The teacher questionnaire was developed to measure teachers' demographic information (age, educational experience), perceived school support, ICT self-efficacy, and teachers' technology integration. All the items in the three scales are 5-point Likert scale. Detailed descriptions of these items are shown in Appendix B.

Teachers' perceived school support A 5-item scale was designed to measure teachers' perceived school support. This study's conceptualization of teachers' perceived school support is based on related research (Chou & Chou, 2021; Dong et al., 2020; Lin et al., 2019). In the scale of Chou and Chou (2021), teachers' perceived school support was identified as teachers' perceptions of administrators' care about their needs and assistance. Dong et al. (2020) mentioned similar administration support as teachers' perceived school support. They also added perceived collegial support as part of teachers' perceived school support. The scale of this study designed and selected items regarding these characteristics. Moreover, the operationalization of perceived school support aligns with the identified empirical evidence for school support. In other words, the items in this scale correspond to items in the school administrator questionnaire. The scale includes teachers' perceptions of school technology support, online systems, technology innovation, and training, which reflected whether school support could meet teachers' demands.

ICT self-efficacy Based on the research conducted by Wang and Zhao (2021), a scale consisting of 3 items was developed to measure teachers' ICT self-efficacy. The scale of Wang and Zhao (2021) assessed teachers' ICT self-efficacy in operational skills and its application for teaching purposes. The descriptions of each item in the new scale drew on their study. The scales covered teachers' confidence in their competence to utilize technology in teaching.

Teachers' technology integration The scale for measuring teachers' technology integration was developed considering the scales of Dong et al. (2020) and Wu et al. (2022). The scales of both two studies mainly contain items describing teachers' capability in designing curricula and promoting professional development with technology. This scale accordingly contains the extent to which teachers integrated digital resources, online systems, and technological devices in teaching and learning.

3.3 Data screening and analytic model

The data was analyzed using MPlus 8.3. By applying MSEM, this study calculated the cluster means among teachers within the same school at the teacher level, introducing these as latent variables at the school level to construct the school-level model (Preacher et al., 2010). Evidence shows that an organization's context impacts individual variables and the relationships between them (Bamberger, 2008). In this case, since teachers within the same school receive similar support, their responses are not independent of one another. In other words, a degree of similarity might be observed among teachers in the same school and greater variability among teachers in different schools. Drawing similar assumptions about teachers across different schools can lead to inaccuracies. Nonetheless, MSEM yields more precise and unbiased parameter estimates (coefficients) by counting standard errors from both within and between levels (Kaplan & Ferguson, 1999). Therefore, it becomes necessary to analyze teachers' nested data by multilevel modeling methods. What's more, the collective perception of individuals within an organization can be aggregated into an overall impression (James & James, 1989). This implies the appropriateness of aggregating organizational-level variables from individual-level variables, an approach recently adopted in the context of education (Hsieh et al., 2022; Li & Petersen, 2022).

In this study, three school-level variables were aggregated from teachers' perceived school support, ICT self-efficacy, and technology integration. They were correspondingly regarded as teachers' shared perception of school support, collective ICT efficacy, and overall technology integration. Given the existing evidence supporting teacher-level relationships, this study further assumes similar relationships at the school level.

4 Result

4.1 Reliability and validity of the scales

To evaluate the psychometric integrity of each scale, a thorough assessment of their reliability and construct validity was conducted through coefficient alpha and Confirmatory Factor Analysis (CFA). Items in the original questionnaire were selected according to the examination. Firstly, as delineated in Table 1, both the Composite Reliability (CR) and Cronbach's alpha values of all scales exceeded 0.8, signifying good internal consistency across the instruments. Moreover, the factor loading of each item surpassed 0.7, and the Average Variance Extract (AVE) was above 0.6, indicating strong convergent validity. The result showed that the final scales used in this research had high reliability and validity.

4.2 Descriptive statistics and correlations

To exclude the influence of demographic variables on administrators and teachers, some demographic information was also investigated in the administrator and teacher questionnaires. They were added to the model as control variables as well.

Table 1 The validity and reliability of the final questionnaire

| Construct | Item | Factor loading | Cronbach's alpha | CR | AVE |
|----------------------------------|--------|----------------|------------------|-------|-------|
| School support | SS1 | 0.786 | 0.860 | 0.900 | 0.644 |
| | SS2 | 0.829 | | | |
| | SS3 | 0.824 | | | |
| | SS4 | 0.762 | | | |
| | SS5 | 0.755 | | | |
| Perceived school support | PSS1 | 0.733 | 0.877 | 0.911 | 0.674 |
| | PSS2 | 0.866 | | | |
| | PSS3 | 0.881 | | | |
| | PSS4 | 0.899 | | | |
| | PSS5 | 0.705 | | | |
| ICT self-efficacy | ICTSE1 | 0.930 | 0.927 | 0.954 | 0.873 |
| | ICTSE2 | 0.932 | | | |
| | ICTSE3 | 0.941 | | | |
| Teachers' technology integration | TTI1 | 0.913 | 0.924 | 0.946 | 0.815 |
| | TTI2 | 0.929 | | | |
| | TTI3 | 0.899 | | | |
| | TTI4 | 0.869 | | | |

The results of demographic variables were encoded. Three demographic variables for teachers were selected. They are teachers' age (1 = Under 20, 2 = 20–30, 3 = 31–40, 4 = 41–50, 5 = Above 50), seniority (1 = Under 10, 2 = 10–20, 3 = 21–30, 4 = Above 30) and degree (1 = Junior college or below, 2 = Bachelor, 3 = Master and above).

In the administrator questionnaire, four demographic variables were chosen, including school location (1 = Urban, 2 = Rural), school type (1 = Primary School, 2 = Junior High School, 3 = Senior High School), administrators' degree (1 = Junior college or below, 2 = Bachelor, 3 = Master and above) and administrators' seniority (1 = Under 10, 2 = 10–20, 3 = 21–30, 4 = Above 30). The descriptive statistics are illustrated in Tables 2, 3. Most of the participants have worked for 10–20 years and hold the undergraduate degree; the number of schools in urban and rural areas is similar. Table 4 shows the correlations at two levels, and it was found that all the latent variables at two levels were significantly correlated.

4.3 Nested structure of data

Because teachers are nested into schools, the statistical justification to aggregate teacher-level variables as school-level variables were investigated. Three aggregation statistics were examined to analyze the aggregation of school-level variables: ICC (1), ICC (2), and Rwg. Table 3 presents the within-group agreement and interrater reliability. ICC (1) ranges from 0.077 to 0.127, indicating acceptable reliability for conducting multilevel analysis. And the ICC (2) also suggests the construct could be aggregated to a higher level. The Rwg, indicating whether it is reasonable and

Table 2 Descriptive statistics

| Variable | Mean | SD |
|------------------------------------|------|------|
| Teachers' seniority | 2.22 | 1.00 |
| Teachers' degree | 1.96 | 0.38 |
| Teachers' age | 3.36 | 0.97 |
| Teachers' perceived school support | 3.71 | 0.66 |
| ICT self-efficacy | 3.63 | 0.69 |
| Technology integration | 3.76 | 0.64 |
| School Location | 1.47 | 0.50 |
| School Type | 1.46 | 0.57 |
| Administrators' seniority | 1.83 | 0.67 |
| Administrators' degree | 1.98 | 0.25 |
| School support | 3.58 | 0.77 |

Table 3 Within-group agreement and interrater reliability

| | Teachers' perceived school support | ICT self-efficacy | Technology integration |
|----------|------------------------------------|-------------------|------------------------|
| R_{wg} | 0.923 | 0.902 | 0.932 |
| ICC(1) | 0.127 | 0.077 | 0.082 |
| ICC(2) | 0.743 | 0.633 | 0.648 |

R_{wg} within-group agreement, ICC intraclass correlation coefficient

meaningful to aggregate variables to the school level, was higher than the accepted threshold of 0.70. As a result, we could aggregate all latent variables that are initially at the teacher level as school-level variables.

4.4 Multilevel structural equation model evaluation

A multilevel model was constructed for analyses. The model fit was examined, obtaining acceptable results ($p=0.000$, $CFI=0.982$, $TLI=0.962$, $SRMR$ (within level)=0.070, $SRMR$ (between levels)=0.069, and $RMSEA=0.036$). The results of relationships at the teacher and school levels are shown in Fig. 2 and Table 5.

At the school level, both teachers' shared perception of school support ($b=0.345$, $p=0.01$) and collective ICT efficacy ($b=0.526$, $p<0.001$) were positively related to teachers' overall technology integration. However, school support did not exhibit a statistically significant direct correlation with teachers' overall technology integration ($b=0.002$, $p=0.757$) and collective ICT efficacy ($b=-0.016$, $p=0.161$). But there were positive relationships between school support and teachers' shared perception of school support ($b=0.111$, $p<0.001$) as well as teachers' shared perception of school support and collective ICT efficacy ($b=0.762$, $p<0.001$). Moreover, school support had a significant and positive indirect association with teachers' overall technology integration, through the chain of two mediators (unstandardized estimate of the product of coefficients= 0.074 , $p<0.001$, 95% MC CI= 0.042 , 0.101).

Table 4 Correlations at the teacher level and the school level

| Teacher level variables | Teachers' seniority | Teachers' degree | Teachers' age | Teachers' perceived school support | ICT self-efficacy | Technology integration | | |
|---|---------------------|------------------|---------------------------|------------------------------------|-------------------|---|-------------------------|--------------------------------|
| Teachers' seniority | | | | | | | | |
| Teachers' degree | -0.309** | | | | | | | |
| Teachers' age | -0.906** | -0.288** | | | | | | |
| Teachers' perceived school support | -0.103** | 0.023** | -0.110** | | | | | |
| ICT self-efficacy | -0.151** | 0.074** | -0.146** | 0.552** | | | | |
| Technology integration | -0.150** | 0.075** | -0.145** | 0.652** | 0.691** | | | |
| School level variables | School location | School type | Administrators' seniority | Administrators' degree | School support | Teachers' shared perception of school support | Collective ICT efficacy | Overall technology integration |
| School location | | | | | | | | |
| School type | 0.040 | | | | | | | |
| Administrators' seniority | -0.084 | 0.153** | | | | | | |
| Administrators' degree | -0.051 | 0.104 | 0.132* | | | | | |
| School support | -0.166** | -0.087 | 0.182** | 0.118* | | | | |
| Teachers' shared perception of school support | -0.077 | -0.232** | 0.041 | 0.066 | 0.310** | | | |
| Collective ICT efficacy | -0.120* | -0.140* | 0.069 | 0.095 | 0.227** | 0.771** | | |
| Overall technology integration | -140* | -0.090 | 0.096 | 0.147* | 0.279** | 0.835** | 0.855** | |

* $p < 0.05$ ** $p < 0.01$

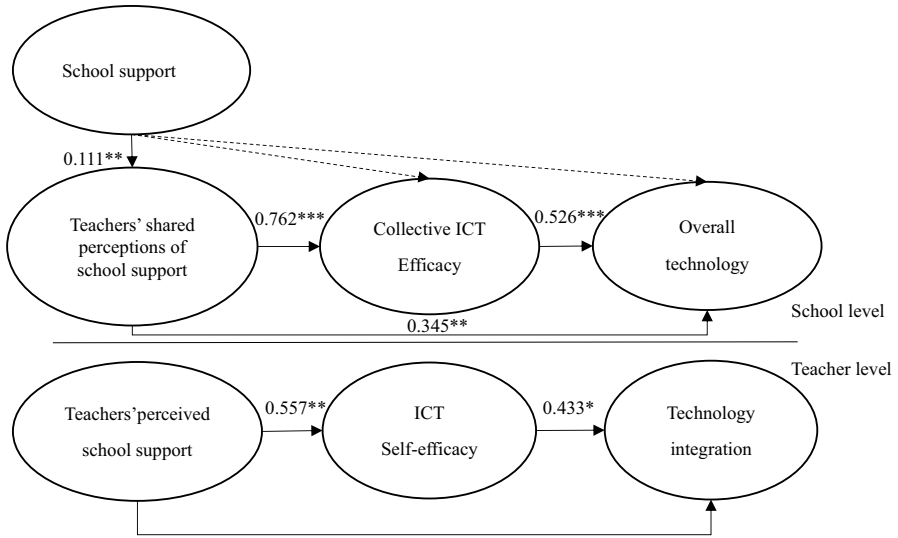


Fig. 2 The multilevel structural equation model tested in the current study. **Note.** * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 5 Result of multilevel structural equation modeling mediation analysis

| Relationships | Between | Within |
|---|----------|----------|
| School support → Teachers' perceived School support | 0.111*** | |
| SE | 0.020 | |
| School support → Teachers' ICT self-efficacy | -0.016 | |
| SE | 0.012 | |
| School support → Teachers' technology integration | 0.002 | |
| SE | 0.008 | |
| Teachers' perceived school support → Teachers' ICT self-efficacy | 0.762*** | 0.557*** |
| SE | 0.042 | 0.014 |
| Teachers' perceived school support → Teachers' technology integration | 0.345** | 0.377*** |
| SE | 0.107 | 0.012 |
| Teachers' ICT self-efficacy → Teachers' technology integration | 0.526*** | 0.433*** |
| SE | 0.133 | 0.012 |
| Product of coefficients | 0.074*** | 0.241*** |
| CI Lower 95% | 0.042 | 0.227 |
| CI Upper 95% | 0.101 | 0.255 |

** $p < 0.01$

*** $p < 0.001$

At the teacher level, teachers' perceived school support ($b=0.377, p<0.001$) and ICT self-efficacy ($b=0.433, p<0.001$) were found to have positive relationships with teachers' technology integration. Moreover, the indirect effect of teachers' perceived school support was significant (unstandardized estimate of the product of coefficients= $0.241, p<0.001, 95\% \text{ MC CI}=0.227, 0.225$). ICT self-efficacy is a partial mediator between teachers' perceived school support and their technology integration both at the two levels.

Overall, these results revealed that H1 and H2 were not supported, and corroborated our H3, H4, H5, and H6 in the conceptual model. They showed that school support only exerts an indirect effect on teachers' technology integration, mediated through teachers' perceived school support. For RQ1, our results indicate that both individual factors mediate the relationships between school support and teachers' technology integration. The effect of teachers' perceived school support is full mediation while teachers' ICT self-efficacy is partial mediation. For RQ2, teachers' ICT self-efficacy emerges as a mediator of the correlation between teachers' perceived school support and technology integration.

5 Discussion

5.1 Relationships in the teacher-level model

At the teacher level, these results reveal that both teachers' perceived school support and ICT self-efficacy significantly predict teachers' technology integration. This outcome aligns with the conclusions drawn by Cai and Tang (2021). They posited that teachers' innovation behavior (i.e., teachers' technology integration) can be predicted by the degree of support they perceive from their supervisors, as well as their self-efficacy. Additionally, our results corroborate the idea that teachers' ICT self-efficacy mediates the relationship between teachers' perceived school support and technology integration, a connection affirmed by other studies previously (Dong et al., 2020; Wang & Zhao, 2021). The finding unveils the role of teachers' ICT self-efficacy, and allows for a deeper understanding of teachers' effective integration of ICT into teaching practices.

Interestingly, these findings can be supported by some TPB-based model studies (Shiue, 2007; Teo et al., 2016). TPB also highlighted the role of teachers' perceptions considering external factors (e.g., perceived behavioral control), which impact teachers' behavioral intention and behavior regarding the use of technology (Atsoglou & Jimoyiannis, 2012). Moreover, in the context of teachers' technology integration, Shiue (2007) explored that teachers' perceived school support could enhance teachers' perceived behavioral control, with teachers' self-efficacy acting as a mediator. The extended TPB model proposed by Teo et al., (2016) also demonstrated a positive correlation between teachers' perceived technology support and their perceived behavioral control. Collectively, studies considering TPB concurred that both teachers' perceived school support and self-efficacy significantly affect teachers' technology integration, with teachers' self-efficacy playing a potential mediating role. The present study contributes further empirical evidence for these.

5.2 Relationships in the school-level model

At the school level, the results validate the presence of serial mediators. Specifically, no direct effect exists between school support and teachers' technology integration. It appears that school support only affects technology integration indirectly, with the mediation of teachers' shared perception of school support. This indicates that school efforts for teachers' change could fall short of effectiveness if teachers' shared perception regarding how the school supports their competence and well-being is not taken into account. The finding is congruent with the tenets of OST (Rhoades & Eisenberger, 2002). Teachers' perceived school support positively connects to their technology integration, validating the empirical connection between OST and teachers' technology integration practice. Moreover, another major finding is that collective ICT efficacy partly mediates the relationships between teachers' shared perception of school support and schools' overall technology integration. This pattern supports the theoretical proposition of the self-efficacy theory. Teachers' ICT self-efficacy relates to their perceived competence and facilitates successful technology integration. Further, this finding underlines the important role of teachers' perceived competence in their technology integration process, as elucidated by a study by Chiu (2022). Chiu (2022) emphasized schools should satisfy teachers' needs for competence by organizing timely professional development activities for teachers.

Although previous studies have presented mixed findings concerning the impact of school support on teachers' technology integration, empirical evidence of this research contradicts the negative effect of school support found by Han et al. (2018) as well as Konstantinidou and Scherer (2022). Furthermore, it is noteworthy that the current results also diverge from some recent evidence suggesting that external support can directly affect teachers' technology integration without mediators (Landa et al., 2023; Yang et al., 2023). The insignificant and negative relationships depicted in these studies may probably be attributed to different contexts or flawed hypotheses. This study selected teachers of K-12 education, whose characteristics vary from teachers of higher and vocational education in other research. Besides, this study supposed teachers' perceived school support and ICT self-efficacy serve as serial mediators. Other studies either supposed only one mediator or overlooked potential mediation from teachers' perceptions and well-being. Nevertheless, schools should support teachers' technology integration externally and internally (Vongkulluksn et al., 2018). Disregarding teachers' feelings, motivation, and emotions, school support could become less effective (Liu & Hallinger, 2017; Peled & Perzon, 2022). This study addresses a gap in the knowledge about the role of and correlation between teachers' perceptions and well-being in their technology integration. Accordingly, the role of teachers' perceptions and well-being should be emphasized for improving school-level technology integration. It adds a more comprehensive understanding of effective school-level ICT integration in education.

6 Implication

6.1 Verification of instruments and influential discoveries

The instruments developed in this study have exhibited reliability and validity, thereby reinforcing the accuracy of the findings. From a practical perspective, the outcomes reveal that the facilitation of school support is contingent upon the inclusion of teachers' perceived school support. Deficiencies in school support can be attributed to an insufficient focus on teachers' perceived school support (Galdames et al., 2018; Jacobs, 2019). Therefore, schools should elevate the emphasis on cultivating teachers' perceptions. Teachers' ICT self-efficacy also exhibits an important role in their technology integration. In conclusion, this study advocates that teachers' efficient technology integration ought to be systematically organized considering resources, policy, as well as teachers' perceptions and well-being.

6.2 Suggestions for creating a supportive school environment

As suggested by the findings, teachers' perceived school support serves as a crucial determinant in improving teachers' technology integration. This accentuates the necessity for schools to underscore the subjective value of teachers to ensure that they perceive a supportive environment. Actions should be initiated to create more supportive cultures, which in turn can boost teachers' perceptions of school support, instead of simply providing more equipment and roles. For example, schools can offer flexibility in determining the best suitable timing and locations for teachers to plan technology implementation, facilitate easy access to training on the utilization of technology resources, as well as arrange interaction between fellow teachers and principals (Davaasuren et al., 2021). Targeted training can engage teachers and stimulate their willingness to use technology resources. Additionally, policies should also encourage the development of a comprehensive supportive school environment that values and supports technology integration. It is crucial that internal and external factors are both taken into consideration by policymakers to provide tangible resources and intangible support mechanisms.

6.3 Suggestions for supporting teachers' well-being

Given the mediating role of teachers' ICT self-efficacy, it necessitates school-level support in offering suitable opportunities and activities to foster teachers' well-being, and acknowledge they possess different levels of ICT self-efficacy (Yurtseven Avci et al., 2020). For instance, it was reported that a gradual rollout of technology can be an effective strategy to uplift teachers who currently harbor lower confidence

in their ICT capabilities. By allowing teacher leaders who already exhibit high ICT self-efficacy and have successfully integrated technology into their classrooms to pave the way, these less confident teachers can draw inspiration. Less-confident teachers could be encouraged by observing the proficient technology implementation of their more confident counterparts, a practice believed to benefit teachers' well-being and stimulate more active participation in technology integration (Yurtseven Avci et al., 2020). It is noteworthy that teachers' well-being, especially positive emotion, is associated with effective engagement and higher job satisfaction (Dreer, 2021). Practices like recognition of successful technology integration efforts and targeted feedback sessions can build teachers' self-efficacy and improve their well-being.

7 Limitation & future direction

While this research surpasses existing literature by adopting OST as the theoretical foundation and constructing a multilevel mediation model with serial mediators, several limitations should be acknowledged. First, this study's conceptualization of school support is somewhat restrictive, being confined to technology resources and policy. It might prove advantageous to consider broader dimensions of school support. This could involve expanding the research scope to include not just school administrators, but other staff members as well, in turn providing a more holistic view of school support. What's more, despite our efforts to include a diverse set of schools in the large-scale data, the sample may not fully capture the characteristics of all teacher populations, especially those in highly alternative educational settings. A more comprehensive picture can be provided by emphasizing these teachers. Future research can also explore the influence of school support from other theoretical viewpoints. This may yield additional insights into the dynamics of teachers' technology integration. The third limitation is that teachers' perceived school support and ICT self-efficacy were selected in this study to represent teachers' perceptions and well-being, yet teachers' subjective value encompasses a more complex connotation and structure. Other factors and their interconnections should be taken into consideration. Researchers are also encouraged to collect longitudinal and qualitative data to identify the mechanism discovered in this study. Longitudinal studies could provide deeper insights into how teachers' dynamic technology integration evolves over time with school support. Additionally, qualitative research exploring teachers' personal experiences with school support and technology integration could enrich the findings of this study as well.

Appendix A

Table 6 School administrator questionnaire items

| Factor | Item | Item description |
|----------------|------|---|
| School support | SS1 | Our school provides online systems/platforms for teachers to manage and evaluate their courses |
| | SS2 | Our school provides online systems/platforms to support learning and teaching in and out of school |
| | SS3 | The online system/platform of our school can be updated on time to meet the basic needs of teaching management in different aspects |
| | SS4 | Our school provides enough classrooms, funding, and technology infrastructure for subject-specific teaching |
| | SS5 | Our school provides evaluation, reward policy, and follow-up service for teachers' technical training |

Appendix B

Table 7 Teacher questionnaire items

| Factor | Item | Item description |
|------------------------------------|--------|---|
| Teachers' perceived school support | TPSS1 | My school provided comprehensive technical support in the whole process of teaching |
| | TPSS2 | My school provided online management systems/platforms for my daily teaching tasks |
| | TPSS3 | My school provided enough support in classrooms, funding, and technology infrastructure for subject-specific teaching |
| | TPSS4 | My school provided me with innovative ideas for integrating technology into teaching |
| | TPSS5 | My school provided me with sufficient technical training |
| ICT self-efficacy | ICTSE1 | I can skillfully teach courses that require using technology |
| | ICTSE2 | I can skillfully use general or subject-specific teaching software in classes |
| | ICTSE3 | I am capable of helping students use technology in their learning |
| Teachers' technology integration | TTI1 | I am familiar with teaching specific subjects in a technology-enhanced environment, and can apply technical devices as well as digital resources |
| | TTI2 | I can use technical devices and online systems to support different learning activities in my teaching, such as self-regulated, cooperative, and inquiry-based learning |
| | TTI3 | I can design open learning activities by applying open educational resources and extramural resources |
| | TTI4 | I believe that applying technology in subject teaching can promote students' learning |

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Declarations

Conflict of interest The authors declare no conflict of interest.

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