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Integrating technology into teaching: Factors influencing rural teachers' innovative behavior

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Abstract
The importance of rural teachers' innovative behavior of integrating technology into teaching (ITT) has been well recognized. Nevertheless, rural teachers' innovative behavior of ITT is far from satisfactory. In order to promote rural teachers' innovative behavior of ITT, it is necessary to better understand what factors are related to it. This study developed a research model of factors related to rural teachers' innovation behavior of ITT based on social cognitive theory (SCT). To verify the model, this study collected surveys from 4090 primary and secondary school teachers in rural areas of China, adopted structural equation modeling to analyze the data. The results indicated that organizational environment, peer support, and information literacy contributed to rural teachers' innovative behavior of ITT, while technostress hindered rural teachers' innovative behavior of ITT. In addition, information literacy mediated the effect of organizational environment and peer support on innovative behavior of ITT, and technostress mediated the effect of peer support and information literacy on innovative behavior of ITT. These findings provide valuable information for teacher training and professional development to promote rural teachers' innovative behavior of ITT.

Keywords Innovative behavior · Innovative teaching · Integrating technology into teaching · Rural teacher · Influencing factors

1 Introduction

With the rapid development of information and communication technology (ICT) in education, the integration of technology into teaching has become important for teachers (Hew & Brush, 2007; Turugare & Rudhumbu, 2020). However, H. H. Yang

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et al. (2018) found that rural teachers were still unable to effectively use ICT or integrate ICT in teaching. How to promote the integration of technology in teaching and the application of ICT has become a major challenge for rural education development (UNESCO, 2020).

Teachers' innovative behavior of integrating technology into teaching (ITT) is considered as teachers proposing innovative ideas and adopting innovative ways to integrate technology into teaching (Chou et al., 2019). In this case, teachers' innovative behavior of ITT has attracted widespread attention as it is considered a key to help teachers keep up to date with the ever-changing society and variety of teaching technologies (Catio, 2019). At present, rural teachers' innovative behavior of ITT is far from satisfactory. Most rural teachers rarely use digital educational resources in teaching activities or display innovative behaviors (Fang et al., 2019). In a three-year long-term study of rural teachers in the United States, Blanchard et al. (2016) found that most teachers cannot use technology innovatively to change their roles or classroom practices. How to encourage rural teachers' innovative behavior of ITT has become an important issue (Song et al., 2014).

Addressing this issue demands a better understanding of what factors are related to teachers' innovative behavior in ICT-based teaching. The social cognitive theory (SCT) emphasizes the impacts of internal and environmental factors on personal behavior (Bandura, 1986), and has been widely applied in many fields (e.g., Ng & Lucianetti, 2016; Wang et al., 2021; Zhu et al., 2019). Based on SCT, some researchers suggested exploring both environment factors and internal factors related to innovative behavior (e.g., Ng & Lucianetti, 2016). In terms of environmental factors, organizational environment and peer support are often mentioned in previous studies (e.g., Gilbert et al., 2020; Irma & Liisa, 2014; Thurlings et al., 2015; Zhu, 2015). For example, Jeong et al. (2019) found that organizational innovation climate is the most significant variable related to rural high school teachers' innovative behavior. Huang et al. (2019) investigated the factors influencing innovative teaching in mainland China, and found that the expectations of students were significant for urban teachers, while school support was a vital factor for rural teachers. Thurlings et al. (2015) pointed out that in order to promote innovative behaviors, teachers need support, guidance, and feedback from others, especially colleagues. Regarding the individual internal factors, the role of information literacy and technostress on rural teachers' innovative behavior of ITT cannot be ignored. Compared with urban teachers, rural teachers have poorer information literacy, especially in terms of information knowledge and information application (Zhou et al., 2020). This may limit the innovative use of technology in teaching (Teo et al., 2017). Moreover, due to limited resources in rural areas, rural teachers had higher levels of technostress (Gabr et al., 2021), which hindered teachers from adopting technology in teaching (Califf & Brooks, 2020; Joo et al., 2016). It is also found that high level of stress has a negative impact on innovation behavior (Lee & Soo, 2016). Therefore, organizational environment, peer support, information literacy, and technostress are of great significance to promoting rural teachers' innovative behavior of ITT. It is necessary to understand the influence of the four factors on rural teachers' innovative behavior of ITT. However, the specific relationship between organizational environment, peer

support, information literacy, technostress, and rural teachers' innovative behavior of ITT is unclear.

For the above reasons, this study regards organizational environment, peer support, information literacy, and technostress as potential factors of rural teachers' innovative behavior of ITT, and constructed a hypothetical model of factors related to rural teachers' innovative behavior of ITT. To verify the model, we analyzed the data collected from 4090 primary and secondary school teachers in rural areas using structural equation modeling. The purpose of this study is to provide further insights into the complex system of rural teachers' innovative behavior of ITT and the relationship between these factors. Furthermore, this study provided some implications concerning how to promote rural teachers' innovative behavior of ITT.

2 Theoretical background

2.1 Teachers' innovative behavior of ITT

Innovative behavior is far more than individual creativity, regarded as a process in which new ideas are created, developed, implemented and modified by humans to benefit role performance (de Jong & Den Hartog, 2007). Janssen (2000) defined innovative behavior as "the intentional creation, introduction and application of new ideas within a work role, group or organization, in order to benefit role performance, the group, or the organization". For teachers, innovative behavior is the process in which teachers implement their creativity into practice and solve difficult situations during their teaching such as bringing forth, developing, applying, promoting, or modifying new ideas (Avsec & Ferk Savec, 2021; Thurlings et al., 2015). In the environment of rapid technological development, teachers not only need to keep up with the changing society, but also pay attention to the upcoming new technologies and new insights about teaching (Thurlings et al., 2015). In this case, high priorities have been given to teachers' innovative behavior of ITT. Teachers' innovative behavior of ITT is considered as teachers proposing innovative ideas and adopting innovative ways to integrate technology into teaching, which can provide many benefits to education quality (Chou et al., 2019). Teachers' innovative behavior of ITT is highly important for education and the future development of students (Thurlings et al., 2015). Specifically, teachers with innovative behavior of ITT can face every challenge in implementing new learning units or a new course, that improves various elements such as the instructional design, the students' competencies, and the teachers' own competencies (Könings et al., 2007).

2.2 Social cognitive theory perspective on innovative behavior of ITT

The social cognitive theory (SCT) emphasizes the impacts of internal and environmental factors on personal behavior (Bandura, 1986), and has been widely applied empirically tests in various contexts and fields (Guo et al., 2018). For example, Zhu et al. (2019) introduced a research model of students' information literacy to discuss the

major factors relating to teenage students' information literacy based on social cognitive theory. Wang et al. (2021) used social cognitive theory to study the determinants of public acceptance, and explored how the trade-off between the perceived benefit and risk affected public acceptance. SCT is a powerful theory of exploring the relationship between the environment, people, and their behaviors, which indicates that people's behavioral patterns are determined by personal and environmental factors (Wang et al., 2021). Behavioral pattern is considered as the "externalization" of values, reflecting individuals' behavioral characteristics and behavioral logic (Wang et al., 2021). In this study, it refers to rural teachers' innovative behavior of ITT. Personal factors are regarded as individuals' beliefs, abilities, and skills. In this study, they refer to rural teachers' information literacy and technostress. Environmental factors are considered as the surrounding conditions on individuals' abilities, skills, and beliefs (Zhu et al., 2019). In this study, they refer to the organizational environment and peer support perceived by rural teachers. In conclusion, to gain more insights into variables explaining rural teachers' innovative behavior of ITT, this study considered the factors related to rural teachers' innovative behavior of ITT as environmental factors (i.e., organizational environment and peer support) and personal factors (i.e., information literacy and technostress) based on SCT.

2.3 Organizational environment

Organizational environment is defined as all the potential factors or powers that influence organizational operation and performance (Robbins, 1996). Tarafdar et al. (2010) proposed that an organizational environment that supports innovation should include encouraging communication and new ideas. Furthermore, Moreira-Fontán et al. (2019) suggested organizational innovation environment support included perceptual support for innovation and creativity, support for the introduction of new and improved ways of doing things, and support for ICT innovation. Informed by these studies, this study regarded the organizational environment as a school environment that supports the implementation of new ideas and innovation in ICT. A favorable organizational environment is essential for supporting teachers to discuss new ideas and participate in innovative practices (Lambriex-Schmitz et al., 2020). Furthermore, environment support can encourage teachers to actively participate in teaching innovation activities. Innovation and organizational atmosphere can predict the performance of teachers' work behavior (Arnold et al., 2007). Lambriex-Schmitz et al. (2020) have investigated the relationship between environmental factors and innovative work behavior at different stages of the innovation process and found that supportive managers and teachers with high exposure to innovation perform better in their innovative behavior. There is a significant positive correlation between the organizational innovation environment and the use of ICT for innovative teaching (Chou et al., 2019). These studies suggest the positive effects of organizational environment on rural teachers' innovative behavior of ITT.

2.4 Peer support

Peer support is that teachers recognize and make use of resources from others in learning (Boud, 2014), share experiences and ideas with their colleagues as well as collaboratively solve teaching problems (Robinson & Schaible, 1995). In the present study, peer support means teachers sharing resources and experience related to technology in teaching work and encouraging those who encounter difficulties. Peer support is considered to be the most cost-effective way to help teacher development (Avalos, 2011). Colleagues in the same institutional context can help each other to overcome hardships to achieve education innovation (Andrews et al., 2016). Knowledge from peers can influence teachers' decision-making of teaching (McConnell et al., 2020). Furthermore, peer support can encourage teachers to adopt new technologies and develop innovative programs (Ching & Hursh, 2014). Some teachers affirmed the positive roles of colleagues in supporting their innovation (Gilbert et al., 2020). In short, the available studies suggest that peer support may exert a strong influence on rural teachers' innovative behavior of ITT.

2.5 Information literacy

Information literacy is usually defined as the ability to acquire, evaluate, organize and use information from various sources (Akarsu, 2011). Teachers' information literacy is a kind of comprehensive quality that teachers purposefully and reasonably use information and information technology (Zhou et al., 2020). It consists of information awareness, information knowledge, information application, information ethics and security, and professional development (Zhou et al., 2020). Teachers' information literacy is the key to the integration and innovation of information technology and education. If teachers lack information literacy, they cannot meet the challenges brought by changing learning methods (Jia, 2019). The higher the information literacy of teachers, the greater intention and ability to integrate information and technology in teaching, and the better teaching efficiency teachers have (Xu & Chen, 2016). With certain internal motivation and teaching goals, teachers' knowledge and technical ability are the keys to carry out educational innovative behavior (De Pablos-Pons et al., 2013). Knowledge has previously been identified as a critical component of the innovation-decision process (McConnell et al., 2020). All in all, these studies suggest that information literacy may have a positive effect on rural teachers' innovative behavior of ITT.

2.6 Technostress

Technostress is related to individuals' pressure of using ICT technology (Berger et al., 2016; Brod, 1984). This study considered technostress as teachers' stress concerning using technologies in teaching, including techno-overload, techno-complexity, techno-insecurity, techno-uncertainty, and techno-invasion (Tarafdar et al., 2007). Recent studies have shown that technostress is the main source of teachers' stress and that K-12 teachers are indeed susceptible to experiencing technostress

related to using technologies (Califf & Brooks, 2020). The continuous emergence of new technologies and new methods of auxiliary teaching leads to teachers' confusion in the selection and use of technologies (Longman, 2013). Stress can suppress a person's creativity and motivate people to look for new coping styles (Kassymova et al., 2019). People who perceive job-related insecurity and anxiety because of techno-insecurity may experience anxiety and low self-confidence when using technology and hence find themselves unable to be innovative at tasks (Tarafdar et al., 2014). Teachers who show technical load will feel that technology has changed their working habits, working methods, and teaching behaviors (Califf & Brooks, 2020), which may further reduce their job satisfaction, innovation, and productivity. Therefore, technostress may be one of the important factors affecting rural teachers' innovative behavior of ITT.

3 Research model and hypotheses

SCT indicates that people's behavioral patterns are determined by environmental and personal factors (Wang et al., 2021). Based on SCT and the previous studies mentioned above, this study aimed to explore the impact of environmental factors (organizational environment and peer support) and personal factors (information literacy and technostress) on rural teachers' innovative behavior of ITT. Moreover, a mounting body of empirical studies has revealed the influence of environmental factors on teachers' personal factors (e.g., Aldridge & Fraser, 2016; F. Yang et al., 2018; Wu et al., 2022). In this case, information literacy and technostress as personal factors may also be affected by environmental factors. Therefore, we consider that organizational environment, peer support, information literacy, and technostress may affect rural teachers' innovative behavior of ITT. Among them, information

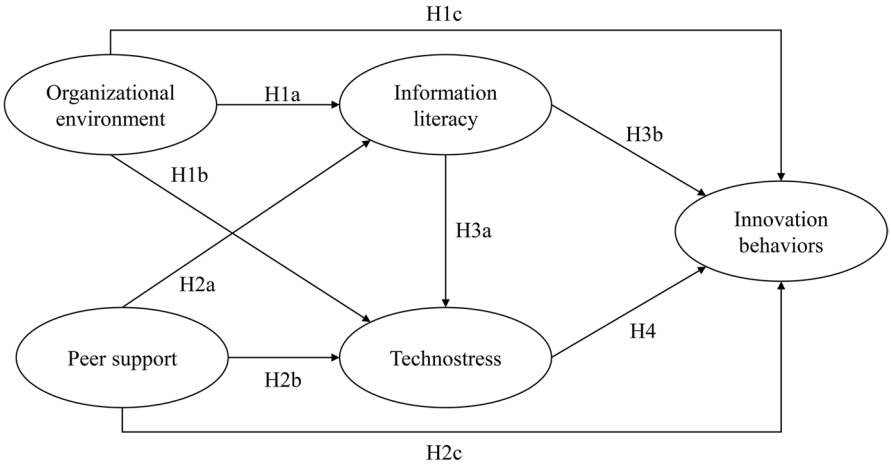

Fig. 1 The hypothetical model of factors related to teachers' innovation behaviors

literacy and technostress may be the mediating factors. Specifically, the research framework and hypotheses are shown in Fig. 1. The following sections summarize the research that has analyzed some of the variables similar to those of the present study and which serve as a basis to formulate part of the hypotheses.

3.1 Organizational environment as predictors of information literacy, technostress, and innovative behaviors

Some empirical research proposed that the organizational environment may have a great influence on teachers' information literacy and technostress. For example, innovative environmental support is conducive to teachers' integration of ICT in the classroom, promoting the interaction of teachers' beliefs, pedagogical knowledge, and technical level, and affecting the effect of educational practice (Jia, 2019). Furthermore, the organizational environment can negatively predict teachers' technical stress (Joo et al., 2016). Providing resource support can help teachers meet job needs and achieve work goals, thereby reducing or helping recover from fatigue (Dicke et al., 2018). Being in an open and innovative environment can alleviate the technostress of teachers to a certain extent (Tarafdar et al., 2011). In addition, research suggests the positive effects of organizational environment on teachers' innovative behaviors. Lambriex-Schmitz et al. (2020) found that a favorable organizational environment is essential for supporting teachers to discuss new ideas and participate in innovative practices. Similarly, Chou et al. (2020) contended that there is a significant positive correlation between the organizational innovation environment and the use of ICT for innovative teaching. Based on these existing research findings, this study proposes the following hypotheses:

Hypothesis 1 (H1). Organizational environment would positively predict information literacy (H1a) and negatively predict technostress (H1b). Organizational environment would positively predict innovative behavior of ITT (H1c).

3.2 Peer support as predictors of information literacy, technostress, and innovative behaviors

Peer support can help teachers to overcome technology adoption barriers, and support teachers to create technological pedagogical content knowledge (TPACK) through the consultation approaches of technology modeling, pedagogical realignment, and deepening practice (Koh, 2020). Furthermore, peer support can reduce teachers' technostress. Teachers can solve technical problems through peer support and cooperation (Granger et al., 2010). A relationship between peer support and innovation behavior has been investigated in previous studies. For example, Ching and Hursh (2014) indicated that peer support can encourage teachers to adopt new technologies and develop innovative programs. Similarly, Gilbert et al. (2020) found that some teachers affirmed the positive

roles of colleagues in supporting their innovation. Based on these antecedents, this study proposes the following hypotheses:

Hypothesis 2 (H2). Peer support would positively predict information literacy (H2a) and negatively predict technostress (H2b). Peer support would positively predict innovative behavior of ITT (H2c).

3.3 Information literacy as predictors of technostress and innovative behavior

Some previous studies have revealed the important role of information literacy in reducing teachers' technostress. When carrying out ICT-based teaching activities, teachers with poor ICT skills are likely to perceive negative emotions such as anxiety and worry (De Pablos-Pons et al., 2013). Tarafdar et al. (2011) indicated that the negative effects of technostress can be dealt with by improving technology awareness. The improvement of teachers' technical literacy level affects the use of technology and reduces their computer anxiety (Celik & Yesilyurt, 2013). Moreover, research suggests that teachers' competence and skills related to information literacy (e.g., knowledge and technical ability) has a positive effect on innovative behavior. For example, De Pablos-Pons et al. (2013) found that teachers' knowledge and technical ability are the keys to carry out educational innovative behavior. Loogma et al. (2012) indicated that teachers' ICT competence was closely related to innovativeness. Based on these findings, this study proposes the following hypotheses:

Hypothesis 3 (H3). Information literacy would negatively predict technostress (H3a) and positively predict innovative behavior of ITT (H3b).

3.4 Technostress as a predictor of innovative behaviors

Kassymova et al. (2019) found the negative relationship between stress and innovation. Furthermore, Califf & Brooks (2020) indicated that technostress could change teachers' working habits, working methods, and teaching behaviors. Similarly, Joo et al. (2016) found technostress had a significant effect on intention to use technology. Therefore, we proposed that teachers with a high level of technostress may seldom propose innovative ideas or adopt innovative ways to integrate technology into teaching. Thus, this study proposes the following hypotheses:

Hypothesis 4 (H4). Technostress would negatively predict innovative behavior of ITT.

3.5 Mediated relations

Based on hypothesis 1–4, the mediating role of information literacy and technostress could be found. Therefore, this study proposes the following hypotheses referring to mediated relationships:

Hypothesis 5 (H5). Information literacy would mediate the effects of organizational environment on innovative behavior of ITT (H5a) and the effects of peer support on innovative behavior of ITT (H5b).

Hypothesis 6 (H6). Technostress would mediate the effects of organizational environment on innovative behavior of ITT (H6a) and the effects of peer support on innovative behavior of ITT (H6b).

Hypothesis 7 (H7). Technostress would mediate the effects of information literacy on innovative behavior of ITT.

4 Methods

An online survey (including an online questionnaire and an online test paper) of primary and secondary school teachers in rural areas in northern China was conducted to test and revise the hypothetical model based on collected data. This section describes the data collection procedure and the participants of the study, the instruments, and data analyses.

4.1 Procedure and participants

A convenient sampling method was used to collect data through an online survey. Specifically, by contacting the provincial departments responsible for ICT in education, we recruited participants by sending a hyperlink or QR code to teachers. A total of 4313 primary and secondary school teachers in rural areas in China volunteered to participate in this survey. The survey was conducted in November 2020 and lasted for a week. To ensure that more participants complete this survey, a brief description of this survey was sent to teachers through the provincial departments responsible for ICT in education. This brief description is as follows: a) this survey is supported by the provincial departments responsible for ICT in education; b) the results of this survey does not have any negative impact on teachers and schools. In this case, most of the participants completed the online survey.

Finally, 4090 responses (the response rate was 94.83%) were included in this study after excluding the incomplete, invalid, or repeated questionnaires. Among the 4090 participants, 82.54% were female teachers. Furthermore, primary school teachers accounted for 65.94%. More detailed information about the participants is shown in Table 1.

4.2 Instruments

4.2.1 Questionnaire

A questionnaire was developed by integrating previously validated instruments to measure innovative behavior of ITT, organizational environment, peer support,

Table 1 Basic information statistics of participants in this study (N = 4090)

Variables	Categories	Number of teachers	Percentage of teachers
Gender	Male	714	17.46
	Female	3376	82.54
Age	Less than 26 years old	339	8.29
	26 to 35 years old	1243	30.39
	36 to 45 years old	1729	42.27
	46 to 55 years old	735	17.97
	More than 55 years old	44	1.08
Teaching experience	Less than 1 years	606	14.82
	1 to 10 years	1012	24.74
	11 to 20 years	477	11.66
	21 to 30 years	1583	38.7
	More than 30 years	412	10.07
School Type	Primary school	2697	65.94
	Secondary school	1393	34.06

and technostress. The questionnaire consisted of 18 five-point Likert scale items (from 1 = strongly disagree to 5 = strongly agree). To meet the needs of this research, some items have been slightly modified according to the teaching background of rural primary and secondary schools. The details are as follows.

- Based on the innovative behavior scale of Jong and Kemp (2003), a five-item scale was used to investigate rural teachers' innovative behavior of ITT. For example, "I can often come up with innovative ideas about the integration of technology and teaching", and "I often use innovative teaching methods in the classroom, such as project-based teaching."
- The scale of organizational environment was adapted from the scale of Innovation Support (Tarafdar et al., 2010). This scale measured teachers' perceived levels of the school environment that supports teachers' implementation of new ideas and innovation in ICT. This scale included four items. The sample items were "My school provides an open communication environment for teachers", "My school encourages teachers to learn new ICT-related skills", and "Teachers' new ideas about ICT-based teaching are easy to implement."
- According to Lam et al. (2010), a five-item scale was used to investigate teachers' perceived levels of peer support. An example item was "When I encounter difficulties in using technology in teaching, my colleagues will encourage me."
- Based on the technostress scale from Tarafdar et al. (2007), a four-item scale was used to assess the pressure on teachers during the integration of teaching and technology. An example item was "It is too complicated for me to use new teaching-related technologies, and I need to spend a lot of time to understand them."

4.2.2 Test paper

The test paper is an existing instrument called *Information Literacy Assessment Tool for Primary and Secondary School Teachers* (Zhou et al., 2020), which is used to measure the information literacy level of rural teachers. The test paper consisted of 38 multiple-choice items, all of which were scored on a 100-point scale, ranging from 0 to 100 points. The sample items could be found in the previous study (Zhou et al., 2020).

4.3 Data analyses

Exploratory factor analyses (EFA), confirmatory factor analyses (CFA) and structural equation modeling (SEM) were used to analyze the data. Firstly, considering that the questionnaire is newly developed in this research, EFA was used to examine the underlying structure of the questionnaire. Secondly, CFA were applied to evaluate the quality of measurement instruments. Then, SEM was used to verify the proposed theoretical model and the complex relationships between the factors. To evaluate the goodness-of-fit of the models, the following indices were suggested by previous studies (e.g., Byrne, 2010): chi-square divided by degrees of freedom (χ^2/df), the comparative fit index (CFI), the goodness of fit index (GFI), Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). It should be noted that since the chi-square value will continue to increase as the sample size increases, the value of χ^2/df was affected by the sample size (La etal., 1989). Considering the large sample size in this study, the value of χ^2/df has no reference significance. Therefore, we examined other indices for model-fit evaluation, including CFI, GFI, TLI, RMSEA, and SRMR. Finally, the bootstrapping approach was applied to analyze the mediating role of information literacy and technostress. In this study, 5000 bootstrapping samples were used. According to Hayes (2009), the bootstrap estimates indicate a significant indirect effect if the 95%CI does not include zero.

In addition, a Harman's single-factor test was conducted to examine possible common method bias (Podsakoff et al., 2003; Podsakoff et al., 2012) as this study mainly used self-report data. The result indicated that the single largest factor explained 23.98% of the variance, which is far below the threshold of 50%. This suggested that there was no significant amount of common method bias exist in the data.

5 Results

5.1 Preliminary analyses

Prior to conducting the EFA, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity was employed to check the suitability of the analysis. Hutcheson and Sofroniou (1999) suggest that KMO values should be above

Table 2 Model fit results (the measurement model)

Fit indices	Analysis results	Recommended value	Goodness of fit
CFI	0.947	> 0.9	Acceptable
GFI	0.925	> 0.9	Acceptable
TLI	0.939	> 0.9	Acceptable
RMSEA	0.060	<0.08	Acceptable
SRMR	0.065	<0.08	Acceptable

0.5. The KMO value for the data set of the questionnaire was 0.928, yielding that the sampling was sufficient. The χ^2 value of Bartlett's sphericity test for the data set was 56,144.91 ($p < 0.001$, $df = 153$). Both results confirmed that the exploratory factor analysis is favorable for explaining the questionnaire. We used principal components analysis (PCA) with varimax rotation and looked for eigenvalues greater than 1.0. The factor loadings of all items are all above 0.50, ranging from 0.62 to 0.88, which indicated all the items could be included in the questionnaire. As a result, this questionnaire consisted of four constructs: innovative behavior of ITT, organizational environment, peer support, and technostress. These factors explained 74.41% of the total variance.

5.2 Reliability and validity of instruments

We performed CFA to examine the internal reliability, convergent validity, and discriminant validity of each construct. Table 2 shows that the indicator results (CFI = 0.947, GFI = 0.925, TLI = 0.939, RMSEA = 0.060, and SRMR = 0.065) meet the recommended level of acceptance and the research model is robust (Byrne, 2010). Therefore, the model in this study is within an acceptable range in the goodness of fit test. As shown in Table 3, Cronbach's alpha values for all the constructs ranged from 0.71 to 0.95, which exceeded the acceptable level of 0.70. The composite reliability (CR) values ranged from 0.81 to 0.93, which exceeded the acceptable level of 0.60 recommended by Fornell and Larcker (1981). These results indicated that all constructs had good reliability.

Table 3 Cronbach's alpha, CR, and AVE

Variable Name	Cronbach's alpha	CR	AVE
Organizational environment	.91	.86	.60
Peer support	.95	.93	.71
Information literacy	.71	.81	.47
Technostress	.72	.82	.54
Innovative behavior of ITT	.91	.90	.65

CR = composite reliability, AVE = average variance extracted

Table 4 Descriptive statistics and discriminant validity

Variables	Mean	*SD*	OE	PS	IL	TS	IB
Organizational environment	4.14	0.78	**0.775**				
Peer support	4.27	0.73	0.767	**0.842**			
Information literacy	80.32	11.72	0.239	0.226	**0.686**		
Technostress	2.92	0.87	−0.107	−0.12	−0.287	**0.735**	
Innovative behavior of ITT	3.65	0.77	0.477	0.493	0.226	−0.17	**0.806**

Boldface numbers are the square root of the average variance extracted. OE = organizational environment, PS = peer support, IL = information literacy, TS = technostress, IB = innovative behavior of ITT

For assessing the convergent validity, the average variance extracted (AVE) values of organizational environment, peer support, technostress, and innovative behavior of ITT reached the acceptable level of 0.50, but the AVE value of information literacy (0.47) was slightly lower than the 0.50 level. According to Fornell and Larcker (1981), if AVE is less than 0.50 but CR is higher than 0.60, the convergent validity of the construct is still adequate (Lam, 2012). Thus, the convergent validity of all constructs was acceptable.

Discriminant validity is commonly used to test the square root of the AVE that evaluates the correlations between a construct and other constructs. To validate the discriminant validity, the square root of the AVE value of a construct should exceed the correlation coefficients between that construct and others (Fornell & Larcker, 1981). Table 4 lists the mean values, standard deviations, and discriminant validity of all constructs. The findings showed that the square roots of the AVE values were greater than the correlation coefficients between any two constructs. Hence, all constructs have good discriminant validity.

5.3 Structural analysis

Structural equation modeling was constructed to calculate the structural paths among organizational environment, peer support, information literacy, technostress, and innovative behavior of ITT. The indices revealed that the model fit the data well as shown in Table 5. Table 6 shows the results of the structural

Table 5 Model fit results (the structural model)

Fit indices	Analysis results	Recommended value	Goodness of fit
CFI	0.966	> 0.9	Acceptable
GFI	0.951	> 0.9	Acceptable
TLI	0.960	> 0.9	Acceptable
RMSEA	0.048	<0.08	Acceptable
SRMR	0.047	<0.08	Acceptable

Table 6 Results for the structural model

Hypothesis	Hypothetical path	Path coefficient	t-value	Validated results
H1a	OE → IL	0.158	5.083***	supported
H1b	OE → TS	0.007	0.233	not supported
H1c	OE → IB	0.227	11.105***	supported
H2a	PS → IL	0.105	3.468***	supported
H2b	PS → TS	−0.063	−2.105*	supported
H2c	PS → IB	0.287	14.128***	supported
H3a	IL → TS	−0.274	−12.311***	supported
H3b	IL → IB	0.051	3.577***	supported
H4	TS → IB	−0.070	−5.213***	supported

OE = organizational environment, PS = peer support, IL = information literacy, TS = technostress, IB = innovative behavior of ITT. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

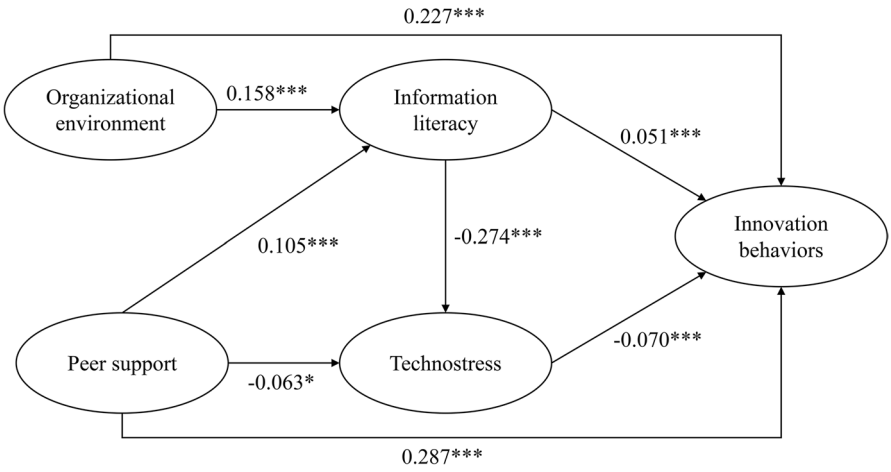

Fig. 2 The final structural model of factors related to innovation behavior

model, and Fig. 2 shows direct effects between organizational environment, peer support, technostress, information literacy and innovative behavior of ITT. In detail, organization environment ($\beta = 0.227$, $p < 0.001$), peer support ($\beta = 0.287$, $p < 0.001$) and information literacy ($\beta = 0.051$, $p < 0.001$) had positive effects on innovative behavior of ITT, while technostress had negative effects on innovative behavior of ITT ($\beta = -0.070$, $p < 0.001$). Organizational environment had positive effects on information literacy ($\beta = 0.158$, $p < 0.001$), while it had no significant impacts on technostress ($\beta = 0.007$, $p = 0.816 > 0.05$). Peer support had positive effects on information literacy ($\beta = 0.105$, $p < 0.001$) and had negative effects on technostress ($\beta = -0.063$, $p < 0.05$). In addition, information literacy had negative effects on technostress ($\beta = -0.274$, $p < 0.001$). Therefore, the proposed

Table 7 Bias-corrected bootstrapped confident intervals of the indirect effects

Hypothesis	Mediation path	Coefficient	S.E.	95% CI	Validated results
H5a	OE → IL → IB	0.008***	0.003	[0.003, 0.014]	supported
H5b	PS → IL → IB	0.005***	0.002	[0.002, 0.011]	supported
H6a	OE → TS → IB	−0.0005	0.002	[−0.005, 0.004]	not supported
H6b	PS → TS → IB	0.004*	0.002	[0.000. 0.009]	supported
H7	IL → TS → IB	0.002***	0.000	[0.001, 0.003]	supported

hypotheses H1a, H1c, H2a, H2b, H2c, H3a, H3b, and H4 were supported, while H1b was not supported.

5.4 Mediation analysis

Table 7 showed the mediating effects of information literacy and technostress. The results revealed that the indirect effect of organizational environment on innovative behavior of ITT through information literacy was statistically significant ($\beta = 0.008$, 95%CI = [0.003, 0.014], $p < 0.001$). Furthermore, the indirect effect of peer support on innovative behavior of ITT through information literacy was statistically significant ($\beta = 0.005$, 95%CI = [0.002, 0.011], $p < 0.001$). These results supported H5a and H5b.

Technostress significantly mediated the effect of peer support on innovative behavior of ITT ($\beta = 0.004$, 95%CI = [0.000, 0.009], $p < 0.05$). The effect of information literacy on innovative behavior of ITT was significantly mediated by technostress ($\beta = 0.002$, 95%CI = [0.001, 0.003], $p < 0.001$). However, technostress did not significantly mediate the impacts of organizational environment on innovative behavior of ITT ($\beta = -0.0005$, 95%CI = [−0.005, 0.004], $p = 0.790 > 0.05$). These results supported H6b and H7, but not H6a.

6 Discussion and implications

6.1 Effects of environmental and personal factors on innovative behavior of ITT

This study provides insights into four significant factors related to rural teachers' innovative behavior of ITT: organizational environment, peer support, information literacy, and technostress. Firstly, the positive role of the organizational environment in promoting rural teachers' innovative teaching has been confirmed. Teachers who get more support from their schools tend to make more innovative behaviors in ICT-based teaching. This result indicated that, to promote rural teachers' innovative behavior of ITT and innovative teaching, rural schools could provide an organizational environment that supports teachers to implement new ideas and ICT innovation. Similarly, Zakaria et al. (2018) also believed that school administration should

provide appropriate support and preparation in facilities and management to meet the needs of teachers, which may promote their smooth classroom teaching.

Secondly, the positive impact of peer support on teacher teaching and innovation is reflected in this research. This result is consistent with previous research, which showed that peers can promote teaching innovation by exchanging new ideas and knowledge (Dancy et al., 2016) or providing innovative decisions and solutions (McConnell et al., 2020). In addition, with the support of colleagues, teachers can deal with teaching problems more easily (Yuan & Zhang, 2016). In-depth teacher cooperation can have a positive impact on teachers' ICT-based teaching and the use of new technologies (Drossel & Eickelmann, 2017). Therefore, improving peer support and strengthening teacher communication is beneficial to promoting rural teachers' innovative behavior of ITT.

Thirdly, this study found that information literacy was significantly related to innovative behavior of ITT. Information literacy is essential for rural teachers to implement innovative behaviors of ICT-based teaching. Similarly, the knowledge of using technology in teaching, as an important part of teachers' information literacy, has been found to promote teachers' innovative behavior to a certain extent in previous studies (e.g., Marthese & Chang, 2018; Thurlings et al., 2015). This is because teachers with high-level information literacy can find the effective information they need on the Internet, integrate information from multiple sources, apply educational technology to teaching practice, and thereby perform better in innovative teaching (Zhu et al., 2013).

Finally, this study revealed that rural teachers with higher technostress were less likely to adopt innovative behavior of ITT in teaching. This may be because technostress can directly or indirectly hinder innovation by reducing the satisfaction of ICT use (Tarafdar et al., 2010), and negatively affect teachers' perceptions and intentions of using ICT in teaching (Joo et al., 2016). This result is in line with other studies suggesting that teachers are often under technical pressure when using technology to assist teaching, which negatively impacts teachers' work behavior and efficiency (Khan et al., 2020).

6.2 The mediating role of information literacy and technostress on innovative behavior of ITT

This study expands the literature on the mediating role of information literacy on innovative behavior of ITT. Specifically, teachers' information literacy partially mediated the effect of organizational environment on innovative behavior of ITT and the effect of peer support on innovative behavior of ITT. In line with previous studies (e.g., Andyani et al., 2020; McConnell et al., 2020), our results indicated that the organizational environment indirectly influenced rural teachers' innovative behavior of ITT by affecting their information literacy. This may be because the support provided by the school (e.g., high-quality personalized training) can improve teachers' information literacy (Chen et al., 2019), which can promote teachers' innovative behaviors (Thurlings et al., 2015). Moreover, peer support could indirectly promote rural teachers' innovative behavior of ITT, with teachers' information literacy acting

as a mediating variable. Therefore, peer support could have a positive impact on teachers' information literacy. This may be because the learning support and guidance of peers can improve teachers' knowledge, skills, and professional abilities (Lyna et al., 2016; Rahman, 2018).

Another major contribution is that this research revealed the mediating role of technostress on rural teachers' innovative behavior of ITT. Technostress partially mediated the effect of peer support on innovative behavior of ITT and the effect of information literacy on innovative behavior of ITT. This result is consistent with the findings of Panisoara et al. (2020), which suggested that technostress had a mediating role in promoting online teaching behavior. Specifically, the support and guidance provided by peers can indirectly promote teachers' innovative behavior of ITT by reducing teachers' technostress. This may be because teamwork and knowledge sharing can effectively reduce teachers' anxiety and stress on technology (Li & Wang, 2021), then help promote teachers' innovative behavior of ITT. Furthermore, improving rural teachers' information literacy can indirectly promote innovative behavior of ITT by reducing their technostress in ICT-based teaching. This may because when teachers improve their technological-pedagogical content knowledge, their anxiety and pressure on technology will decrease (Özgür, 2020).

In sum, in rural primary and secondary school contexts, teachers' innovative behavior of ITT is influenced by the joint impacts of organizational environment, peer support, information literacy, and technostress. Therefore, to promote rural teachers' innovative behavior of ITT and thereby improve the quality of rural teaching, both the professional development of teachers and the construction of the school environment should be taken seriously.

6.3 Implications

6.3.1 Theoretical implications

In view of the need to promote rural teachers' innovative behavior of ITT, this study explores the key factors affecting rural teachers' innovative behavior of ITT relying on a large-scale sample of rural teachers. This research provides new insights for rural teachers' innovative behavior of ITT and has the following two contributions.

First, this study explores factors influencing rural teachers' innovative behavior of ITT from a social cognitive theory perspective. As a widely accepted theory for identifying the main factors affecting individual behaviors and competences, SCT has been used in empirical research on a range of topics (Zhu et al., 2019). Despite the wide application of SCT in various contexts associated with ICT, research on teachers' innovative behavior of ITT remains limited. This study uses SCT to study the influencing factors of rural teachers' innovative behavior of ITT. Based on SCT, this research develops a model of factors related to rural teachers' innovation behavior of ITT. This model provides new

insights for rural teachers' innovative behavior of ITT, and provides a reference for promoting research on rural teachers' innovation behavior of ITT.

Second, we focused on the complex effects of information literacy and technostress on rural teachers' innovative behavior of ITT. Previous studies have mentioned the role of teachers' information literacy and technostress in the integration of technology into teaching (e.g., Califf & Brooks, 2020; Joo et al., 2016; Xu & Chen, 2016). However, little attention has been paid to the specific effect of information literacy and technostress on innovation behavior of ITT. This study not only found the direct impact of information literacy and technostress on rural teachers' innovation behavior of ITT, but also explored their mediating role in the effect of organizational environment and peer support on innovation behavior of ITT. Studying different roles of information literacy and technostress provide a deeper view of how to support the development of rural teachers' innovative behavior of ITT, which could help stakeholders understand the role of teachers' information literacy and technostress in innovative teaching, and also provide valuable information for promoting rural teachers' innovative behavior of ITT.

6.3.2 Practical implications

The findings of this study shed light on the relationship between innovative behavior of ITT, organization environment, peer support, information literacy, and technostress, which provides practical implications for rural school administrators and rural teachers on how to improve the innovative behavior of ITT.

Considering the role of the organizational environment and peer support, rural school administrators can promote rural teachers' innovative behavior of ITT by strengthening school support and peer support, such as providing a platform for sharing innovative teaching ideas (Chou et al., 2019) and establishing structured peer support schemes (Houlston et al., 2009). Based on the mediating role of information literacy and technostress, school administrators can promote innovative behavior of ITT by improving teachers' information literacy and reducing teachers' technostress in ICT-based teaching. In specific, administrators can organize ICT-related training to improve teachers' information literacy and necessary skills for innovative teaching practice (Zakaria et al., 2018). In addition, it is also important for schools to increase support for ICT use (e.g., technical support and professional training) to reduce teachers' technical pressure (Wang & Li, 2019).

Rural teachers can enrich and increase their innovative behavior of ITT through seeking peer support, improving information literacy, and reducing technical pressure. They can actively join innovative teaching theme groups to obtain peer support (Yuan et al., 2018). In this case, when teachers face innovative teaching problems (e.g., how to effectively integrate virtual reality technology with geography teaching courses), group members can provide ideas and suggestions. Furthermore, teachers can join online training communities and seek cooperation and communication to improve personal information literacy (Wang, 2019), and increase confidence in computer use and technology integration capabilities to reduce technostress (Dong et al., 2020).

7 Limitations and conclusion

Although this study has provided valuable insights into factors affecting rural teachers' innovative behavior of ITT, there are some limitations. First, the data collected in this study is only teachers' self-reported responses. To achieve a more comprehensive understanding of rural teachers' innovative behavior of ITT, other qualitative methods (e.g., observation and interview) could be used (Wang et al., 2019). Second, although the impacts of environmental and personal factors related to the innovative behavior of rural teachers have been explored, the understanding of innovative behavior of ITT may be further improved by integrating more factors (e.g., students' information literacy).

Despite these limitations, this study addressed the gap in the literature on rural teachers' innovative behavior of ITT. From an empirical viewpoint, this study found that organizational environment, peer support, and information literacy have positive impacts on teachers' innovative behavior of ITT, while teachers' excessive technostress will hinder teachers' innovative practice behaviors. Therefore, school decision-makers can help teachers carry out innovative teaching practices by providing a favorable organizational environment, creating an atmosphere conducive to peer support, and organizing training to improve teachers' information literacy and reduce teachers' technical pressure.

Declarations None

Conflicts of interest/Competing interests. The authors declare that they have no conflict of interest.

Availability of data and material. Not applicable.

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