

Innovative Work Behaviour in Virtual Learning Environments: Examining the Effects of Technostress, Telepressure and Role Stress with Digital Literacy as a Moderator

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Abstract

This study examines the three stressors of technostress, telepressure, and role stress and their relationship with innovative work behaviour (IWB) among academic staff members who teach students in virtual learning environments (VLEs), and whether digital literacy serves as a moderating factor between these stressors and the dependent variable. The Job Demands–Resources model is used and each stressor is conceptualized as a higher order construct composed of dimensions. This study used a positivist philosophy with a deductive and quantitative approach and data were gathered using a self-administered questionnaire from 384 academic staff of nine academic private universities in Klang Valley, Malaysia, analysed using the partial least squares structural equation modelling (PLS-SEM) in SmartPLS 4 with 10,000 subsamples of the bootstrap. The measurement model had good reliability, convergent and discriminant validity and the weight for all higher-order formative measures and no collinearity. Structural model accounted for the variance of IWB 49.4 % ($Q^2_{\text{predict}} = 0.47$). The findings supported the hypotheses that indicated that technostress ($\beta = -0.42$), role stress ($\beta = -0.39$) and telepressure ($\beta = -0.34$) had significant negative effects on IWB. The extent of digital literacy did not significantly moderate any of the three relationships, and had no direct significant effect, so the fourth hypothesis was not accepted. The results suggest that technology strain hinders educator innovation irrespective of digital-literacy levels and that institutions need to mitigate the strain, not just on the basis of the difference among educators in digital-literacy. The study adds to the technostress and IWB literature the higher order evidence of moderation in a context of higher education in Southeast Asia.

Keywords: Technostress, Telepressure, Role Stress, Innovative Work Behaviour, Digital Literacy

Introduction

Higher education in Malaysia is undergoing a fast transformation to digital and technology adoption has become a key factor in institutional competitiveness. About 417 private higher education institutions with some 420,000 students have proven to be the most dynamic drivers of this change in the national e-learning market, which generated some USD 3.57 billion of revenue in 2024 and is estimated to reach USD 16.16 billion by 2030. Today, a few private universities offer fully online or blended programmes using advanced virtual learning environments (VLEs) equipped with video conferencing, collaborative and assessment technologies, such as Blackboard, Moodle and Canvas, in the Klang Valley.

In such settings the innovative work behaviour of academic staff has emerged as the critical institutional asset. IWB is the deliberate initiation, facilitation, and execution of new ideas, processes or procedures in the workplace that can improve the performance of the person, group or organisation (Janssen, 2000; West & Farr, 1989). The continuous innovation of curriculum design, the use of technology, and pedagogy help to differentiate and maintain quality for institutions (Hassan et al., 2024).

The same technicisation that enables innovation also exposes educators to multiple forms of strain. The negative psychological responses to ICTs are represented by techno-overload, techno-invasion, techno-complexity, techno-insecurity and techno-uncertainty (Tarafdar et al., 2007). Telepressure refers to the need to react immediately to electronic messages, the pressure to respond promptly, the saturation of messages, work–life conflict, and the lack of psychological disconnection (Barber & Santuzzi, 2015; Pfaffinger et al., 2022). Role stress refers to the stress from role ambiguity, role conflict, role overload, and role pressure (Rizzo et al., 1970). While research clearly shows that each stressor negatively impacts educator performance and educator innovation (Bourlakis et al., 2023; Callista & Hastuti, 2024; Chou & Chou, 2021; Yang et al., 2025), few studies have modelled the combined impact of all three stressors on educator performance and innovation in VLEs.

Another question is of individual difference. It is generally believed that digital literacy protects educators from tech strain, but this is still not known if digital literacy conditions the relationship between tech strain and innovation, and if so, whether it has practical significance and can buffer tech strain or whether it rather conditions the choice of reducing tech strain itself by investing in the up-skilling of educators. This study thus investigates how each of these higher-order constructs (technostress, telepressure or role stress) relates to the IWB of teachers in Malaysian private higher education institutions and whether digital literacy plays a moderating role in these relationships.

Despite the growing body of literature examining technology-related stress in higher education, limited empirical research has simultaneously investigated the combined effects of technostress, telepressure, and role stress on innovative work behaviour within virtual learning environments. Furthermore, the extent to which digital literacy may mitigate these relationships remains inconclusive. Addressing these gaps, this study investigates the relationships among these constructs within Malaysian private higher education institutions. The study objectives and research questions are presented below.

Research Objectives

This study aims to:

- **RO1:** Examine the effect of technostress on innovative work behaviour among academic staff in virtual learning environments.
- **RO2:** Examine the effect of telepressure on innovative work behaviour among academic staff in virtual learning environments.
- **RO3:** Examine the effect of role stress on innovative work behaviour among academic staff in virtual learning environments.
- **RO4:** Determine whether digital literacy moderates the relationship between technostress and innovative work behaviour.
- **RO5:** Determine whether digital literacy moderates the relationship between telepressure and innovative work behaviour.
- **RO6:** Determine whether digital literacy moderates the relationship between role stress and innovative work behaviour.

Research Questions

This study seeks to answer the following research questions:

- **RQ1:** What is the effect of technostress on innovative work behaviour among academic staff in virtual learning environments?
- **RQ2:** What is the effect of telepressure on innovative work behaviour among academic staff in virtual learning environments?
- **RQ3:** What is the effect of role stress on innovative work behaviour among academic staff in virtual learning environments?
- **RQ4:** Does digital literacy moderate the relationship between technostress and innovative work behaviour?
- **RQ5:** Does digital literacy moderate the relationship between telepressure and innovative work behaviour?
- **RQ6:** Does digital literacy moderate the relationship between role stress and innovative work behaviour?

Literature Review

Theoretical Underpinnings

The study is mainly based on the Job Demands - Resources (JD-R) model (Bakker & Demerouti, 2007), which sees all jobs as consisting of demands that require sustained effort and resources that aid the achievement of goals. The model addresses a process of health impairment with chronic demands leading to energy depletion and performance degradation and a motivational process where resources promote engagement. Technostress, telepressure, role stress are all considered to be three families of job demand technology specific Tarafdar et al., 2007, communication specific (Barber & Santuzzi, 2015), and role specific (Rizzo et al., 1970), respectively, and digital literacy is considered as a personal resource that can buffer the process of health impairment. The model is also supported by Person Environment Fit Theory by (French et al., 1974) and Social Cognitive Theory by Bandura (1986), both of which consider that strain is a misfit between demands and capability, and that personal resources like digital literacy are part of the factors that shape behaviour. The definition of each stressor is multidimensional by itself; each is identified as a higher-order construct with reflective-formative dimensions following the guidance of higher order modelling in PLS-SEM of Becker et al. (2012) and Sarstedt et al. (2019).

Innovative Work Behaviour

The conceptualisation of innovative work behaviour proposed by West and Farr (1989) was defined as the deliberate and systematic introduction and application of ideas, processes or procedures that are new to the unit, and operationalisation by Janssen (2000) in terms of idea generation, promotion, and implementation. It can be seen in higher education as pedagogical innovation and the creative use of technology (Hassan et al., 2024). Innovation is hard and voluntary, and therefore, it is a good measure to aim for in a demands-based model as it is easily disrupted by cognitive and emotional depletion.

Technostress and Innovative Work Behaviour

Technostress is the conflict that teachers experience when dealing with the intrusiveness, complexity and speed of educational technologies (Brod, 1984; Tarafdar et al., 2007). All five dimensions- techno-overload, techno-invasion, techno-complexity, techno-insecurity and techno-uncertainty constitute the overall technostress (Ragu-Nathan et al., 2008). In Malaysia, technostress has been found to be associated with negative tech-mediated behaviours (Awang Kader et al., 2022); educators are less willing to try new things (Bourlakis et al., 2023; Chou & Chou, 2021; Khan et al., 2022; Yang et al., 2025); and less able to solve problems creatively (Bourlakis et al., 2023; Chou & Chou, 2021; Khan et al., 2022; Yang et al., 2025).

H1: Technostress has a significant negative effect on innovative work behaviour.

Telepressure and Innovative Work Behaviour

Telepressure is the obsession and need to quickly respond to electronic messages (Barber & Santuzzi, 2015). Round-the-clock communication in VLEs can cause pressure to respond quickly, create communication overload, and increase chances of work-life conflict, with a significant impact on psychological detachment, ultimately impacting recovery and innovation (Pfaffinger et al., 2022; Semaan et al., 2025).

H2: Telepressure has a significant negative effect on innovative work behaviour.

Role Stress and Innovative Work Behaviour

The demands of role are called role stress (Kahn et al., 1964; Rizzo et al., 1970). Traditional academic roles have been blurred in the context of virtual teaching, causing role ambiguity, conflict, overload and pressure, which can negatively impact the psychological safety needed for risk-taking and innovation for academics (Cotos-Gamarra et al., 2023).

H3: Role stress has a significant negative effect on innovative work behaviour.

The Moderating Role of Digital Literacy

Digital literacy refers to an educator's ability to use, evaluate, select, and adapt digital technologies for teaching and learning. As a personal resource in the JD-R model, it is expected to moderate the health-impairment process, reducing the negative impact of technological strain on innovation: Educators who are more digitally literate will more likely judge technological demands as manageable challenges instead of threats, leading them to have more capacity to innovate when under stress (Bandura, 1986). The moderating role of

digital literacy remains viable, even though there are no evidence for the strain–innovation relationship, thus, the digital literacy is tested for each of the three stressors.

H4: Digital literacy moderates the relationships between (a) technostress, (b) telepressure, and (c) role stress and innovative work behaviour, such that the negative effects are weaker at higher levels of digital literacy.

Research Framework

Figure 1 presents the research framework for this study.

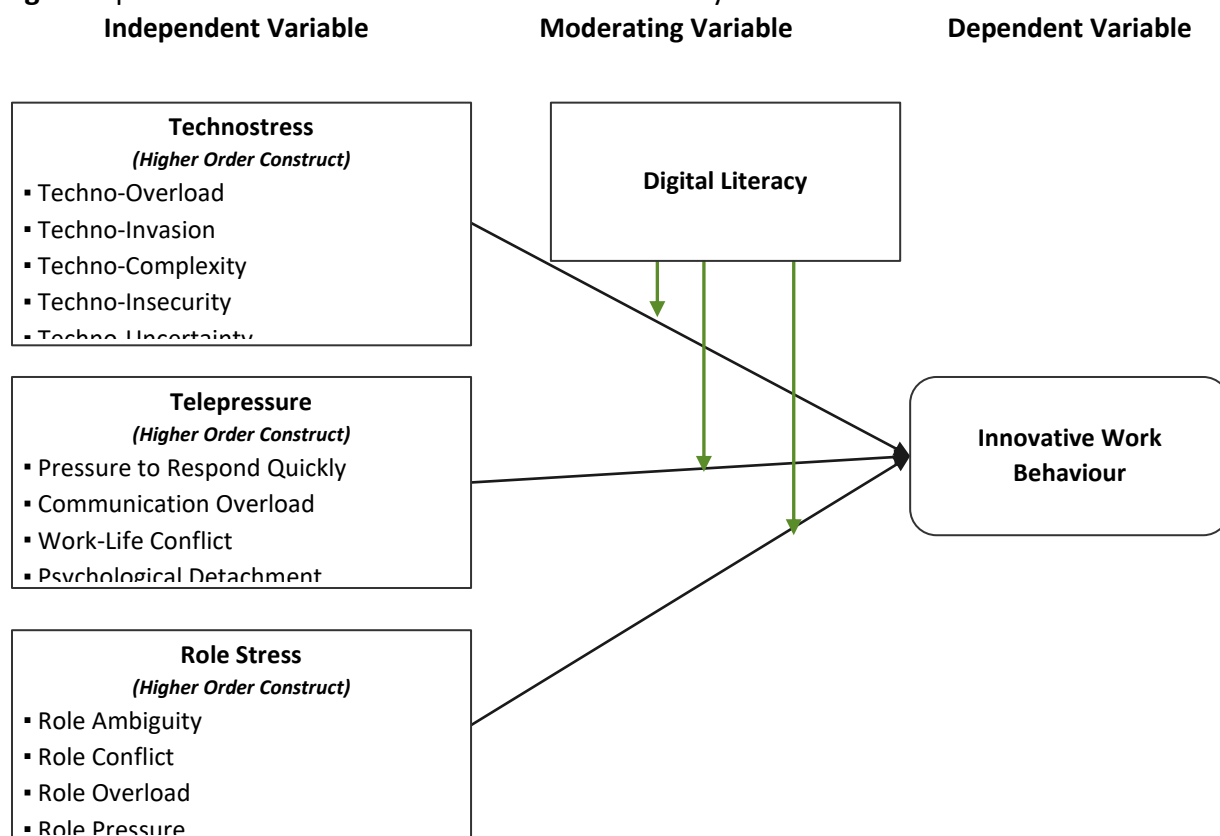


Figure 1 Research Framework

Methodology

Overall Design, Target Population, Sampling, and Sample Size

This research is based on positivist philosophy and uses deductive research with quantitative and cross-sectional approach. The target population comprised about 1,800 academic staff, who delivered courses using VLEs, in nine private universities of Klang Valley, Malaysia, where they had at least one year of experience in using VLEs. The nine universities were selected purposively because they had an institution wide VLE, and then a non-probability quota sampling technique was employed, where the quota by institution and discipline was proportionate to the number of heads. According to Krejcie and Morgan (1970), a minimum of 317 respondents is needed for a population of 1,800; and the results obtained from this study with 384 valid responses is greater than the minimum requirement and meets the rules of thumb for PLS-SEM (Hair et al., 2021; Memon et al., 2020).

Instrumentation

Academic staff were invited to complete an online questionnaire. Demographic data was gathered in Section A. The constructs of the studied variables were measured on a 5-point Likert scale with instruments adapted for the VLE context: Technostress (25 items, 5 dimensions) from Tarafdar et al. (2007); Telepressure (20 items, 4 dimensions) from Barber and Santuzzi (2015); role stress (20 items, 4 dimensions) from Rizzo et al. (1970); and IWB (15 items) from Janssen (2000), re-anchored to the teaching context. Digital literacy was measured as one item self-assessment on digital/IT literacy which was moderated by the study. All items were content validated by content experts and pilot tested prior to administration.

Higher-Order Construct Specification

Each stressor was modelled as a reflective-formative (Type II) higher-order construct, and higher-order constructs were created by the dimensions of each stressor (the five dimensions of technostress, four dimensions of telepressure, and four dimensions of role stress). In the first stage, the scores of the first order latent variables were calculated, and in the second stage, the scores of the three higher-order constructs, together with digital literacy and the three interaction terms, were used to predict IWB. The model was estimated using the two-stage approach recommended for higher-order constructs in PLS-SEM (Becker et al., 2012; Sarstedt et al., 2019).

Data Collection and Data Analysis

Self-administered questionnaires were sent out for three months and 384 questionnaires were returned, of which 384 were edited and coded to get valid data. The data were analysed using SPSS and SmartPLS 4 was used to test the measurement and structural models. The reasons for using PLS-SEM over covariance-based SEM were that the model incorporates both reflective and formative measurement in a higher-order structure with interaction effects, it is prediction-oriented, and it is robust to non-normality (Hair et al., 2021). The reliability and the convergent and discriminant validity of reflective first-order constructs were examined, as well as their weight significance in formative higher-order constructs, the collinearity of the constructs, R², effect size (f²), predictive relevance (Q²predict), model fit (SRMR), path significance, and moderation of the structural model. Harman's single-factor test and the full-collinearity approach (Kock, 2015) were used to test for common method bias. A 10,000-subsample bootstrap was used to obtain significance.

Results

Demographic Information of Respondents

There were 384 respondents. Note that the moderator is digital literacy, with a distribution of 22 respondents (5.7%) rated their digital literacy as beginner, 120 (31.2%) as intermediate, 186 (48.4%) as advanced, and 56 (14.6%) as expert, so 63.0% were at the two highest levels. The sample also reported a mean teaching experience of 12.09 years and a mean VLE experience of 5.07 years.

Reliability

The measurement model was used to get the reliability and validity data presented in Table 1 through the use of SmartPLS. The standardised indicator loadings were all higher than 0.708 across the board (range 0.813 – 0.916). The alpha coefficient for the Cronbach was not lower

than 0.70, the reliability coefficient for the rho_A was not lower than 0.70, and the composite reliability for rho_C was not lower than 0.70 (Hair et al., 2021), which means that there was no violation of reliability.

Table 1

Reliability and Validity – Measurement Model

Construct	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	AVE
Technostress				
Techno Overload	.920	.925	.940	.758
Techno Invasion	.936	.938	.952	.797
Techno Complexity	.927	.933	.945	.775
Techno Insecurity	.941	.949	.955	.809
Techno Uncertainty	.932	.948	.948	.786
Telepressure				
Responding Quickly	.931	.993	.945	.776
Communication Overload	.920	.932	.940	.757
Work Life Conflict	.937	.943	.952	.799
Psychological Detachment	.939	.950	.953	.802
Role Stress				
Role Ambiguity	.925	.928	.944	.770
Role Conflict	.932	.935	.948	.786
Role Overload	.933	.948	.949	.789
Role Pressure	.926	.934	.944	.772
Dependent variable				
Innovative Work Behaviour	.974	.975	.977	.735

Note: N = 384. AVE = average variance extracted.

Convergent Validity

Convergent validity was verified using the average variance extracted (AVE) and the value must be 0.50 or more (Hair et al., 2021). As indicated in Table 1, the AVE values of all constructs are in the range of 0.735 to 0.809, which means each construct accounts for most of the variance in its indicators and convergent validity is supported.

Discriminant Validity

The Fornell–Larcker criterion (Table 2) and the heterotrait–monotrait ratio (Table 3) were used to assess the discriminant validity among the first-order constructs. The AVE for all constructs exceeded their correlations with all other constructs and all HTMT were < 0.85 (with maximum of 0.263), thus not violating discriminant validity (Henseler et al., 2015). The uniform low correlations are consistent with the dimensions being separate facets and thus make it appropriate to use the reflective-formative higher-order specification.

The final performance tasks for each of the higher-order constructs is formative.

The three higher-order constructs were measured as formative composites of their dimensions (Table 4). There was no collinearity, given that all formative-indicator VIF values were near 1.0 (well below the threshold of 3.3), and all dimensions had significant weight ($p < 0.001$), indicating that they all meaningfully contribute to the construct.

Table 2

Discriminant Validity – Fornell–Larcker Criterion

	CO	RQ	PD	WLC	RA	RC	RO	RP	TO	TIV	TC	TIS	TU	IWB
CO	0.87													
RQ	-	0.88												
	0.02													
PD	-	-	0.90											
	0.07	0.02												
WLC	0.05	0.02	-	0.89										
			0.03											
RA	0.03	-	-	0.06	0.88									
		0.02	0.01											
RC	0.03	-	0.04	-	0.08	0.89								
		0.03		0.03										
RO	0.01	-	-	0.09	-	0.04	0.89							
		0.01	0.01		0.00									
RP	0.05	-	0.07	0.06	-	-	-	0.88						
		0.06			0.00	0.03	0.01							
TO	-	-	0.02	0.10	0.02	-	-	0.06	0.87					
	0.01	0.02				0.06	0.04							
TIV	0.11	-	-	0.08	0.04	0.06	0.02	-	0.05	0.89				
		0.04	0.01					0.03						
TC	0.01	-	0.01	-	0.01	0.01	-	0.11	0.06	0.04	0.88			
		0.04		0.07			0.07							
TIS	-	-	0.00	-	-	0.06	-	-	-	-	0.04	0.90		
	0.01	0.03		0.02	0.00		0.03	0.06	0.03	0.02				
TU	0.13	-	0.04	0.01	0.00	-	0.00	0.02	0.01	-	0.02	-	0.89	
		0.01				0.05				0.01		0.01		
IWB	-	-	-	-	-	-	-	-	-	-	-	-	-	0.86
	0.23	0.07	0.19	0.25	0.22	0.19	0.21	0.24	0.25	0.22	0.17	0.21	0.20	

Note: N = 384. Diagonal (bold) = square root of AVE. CO = communication overload; RQ = responding quickly; PD = psychological detachment; WLC = work–life conflict; RA = role ambiguity; RC = role conflict; RO = role overload; RP = role pressure; TO = techno-overload; TIV = techno-invasion; TC = techno-complexity; TIS = techno-insecurity; TU = techno-uncertainty; IWB = innovative work behaviour.

Table 3

Heterotrait–Monotrait Ratio (HTMT)

	CO	RQ	PD	WLC	RA	RC	RO	RP	TO	TIV	TC	TIS	TU	IWB
CO														
RQ	0.05													
PD	0.08	0.05												
WLC	0.05	0.03	0.04											
RA	0.05	0.04	0.04	0.07										
RC	0.04	0.05	0.05	0.04	0.09									
RO	0.04	0.03	0.04	0.09	0.04	0.04								
RP	0.05	0.08	0.08	0.06	0.02	0.04	0.03							
TO	0.03	0.04	0.04	0.11	0.05	0.06	0.07	0.07						
TIV	0.12	0.04	0.03	0.09	0.05	0.07	0.03	0.05	0.06					
TC	0.03	0.06	0.03	0.07	0.04	0.03	0.08	0.12	0.07	0.04				
TIS	0.04	0.05	0.03	0.04	0.02	0.06	0.05	0.07	0.04	0.04	0.05			
TU	0.14	0.03	0.05	0.04	0.03	0.06	0.03	0.05	0.03	0.03	0.04	0.04		
IWB	0.24	0.07	0.20	0.26	0.23	0.20	0.22	0.25	0.26	0.23	0.18	0.21	0.21	

Note: N = 384. All HTMT ratios are below 0.85. Abbreviations as in Table 2.

Formative Measurement of the Higher-Order Constructs

Establishing the first order measures, the three higher order constructs were measured as formative composites of the dimensions (Table 4). All the formative-indicator VIFs were close to 1.0 (well below 3.3) and all the dimensions had significant weights ($p < 0.001$), which means that each dimension is an actual contributor to the construct.

Table 4

Formative Measurement of the Higher-Order Constructs

Dimension (lower order)	Weight	Loading	VIF	Sig.
Technostress				
Techno Overload	.445	.488	1.007	***
Techno Invasion	.431	.459	1.005	***
Techno Complexity	.472	.539	1.007	***
Techno Insecurity	.402	.397	1.003	***
Techno Uncertainty	.411	.415	1.001	***
Telepressure				
Responding Quickly	.516	.507	1.002	***
Communication Overload	.502	.483	1.008	***
Work Life Conflict	.547	.569	1.003	***
Psychological Detachment	.462	.399	1.006	***
Role Stress				
Role Ambiguity	.505	.544	1.007	***

Dimension (lower order)	Weight	Loading	VIF	Sig.
Role Conflict	.513	.560	1.009	***
Role Overload	.485	.500	1.002	***
Role Pressure	.452	.432	1.001	***

Note: N = 384; 10,000 bootstrap subsamples. VIF threshold < 3.3. *** p < 0.001.

Multicollinearity: Inner Model

The collinearity was checked in the inner model by using the variance inflation factor (VIF). According to Hair et al. (2021), a value of less than 3.3 for all inner-model VIF values indicates no collinearity problem with the model, as can be seen from Table 5, all VIF values are within the range of 1.01 to 1.04, therefore the model has no collinearity problem, and common method bias is not a problem as recommended by Kock (2015). This was confirmed by Harman's single factor test which gave 17.1% variance in the first factor which was less than 50%.

Table 5

Variance Inflation Factor – Inner Model (VIF)

Relationship	VIF
Technostress -> IWB	1.027
Telepressure -> IWB	1.019
Role Stress -> IWB	1.013
Digital Literacy -> IWB	1.042
Digital Literacy x Technostress -> IWB	1.014
Digital Literacy x Telepressure -> IWB	1.020
Digital Literacy x Role Stress -> IWB	1.021

Note: N = 384. All VIF values are below the 3.3 threshold.

Coefficient of Determination (R-Square) and Predictive Relevance

The $R^2 = 0.494$ means that the model explains 49.4% of the variance in IWB (adjusted $R^2 = 0.484$), which is considered a moderate to significant level (Hair et al., 2021). The cross-validated $Q^2_{predict} (+0.466)$ supported out-of-sample predictive relevance, and the model fit was acceptable (SRMR = 0.032, < 0.08). See Table 6.

Table 6

R-Square and Predictive Relevance

Endogenous Construct	R-Square	R-Square Adjusted	$Q^2_{predict}$
Innovative Work Behaviour	0.494	0.484	0.466

Note: N = 384.

Path Coefficients (Test of Hypotheses)

Hypothesis testing was carried out with 10,000 subsamples and a t value greater than 1.96 and a p value less than 0.05 are considered significant. As shown in Table 7 and Figure 2, technostress ($\beta = -.420$, $p < 0.001$), role stress ($\beta = -.391$, $p < 0.001$), and telepressure ($\beta = -.343$, $p < 0.001$) each had a significant negative effect on IWB, with large-to-medium effect sizes ($f^2 = 0.340$, 0.298 , and 0.228 respectively). Thus, the hypotheses, H1, H2, and H3, were accepted.

Table 7

Path Coefficients (Test of Hypotheses)

Relationship	Original Sample (O)	T Statistics	P Values	f^2	Decision
H1: Technostress -> IWB	-.420	10.790	0.000	0.340	Supported
H2: Telepressure -> IWB	-.343	9.330	0.000	0.228	Supported
H3: Role Stress -> IWB	-.391	10.910	0.000	0.298	Supported
Digital Literacy -> IWB	-.018	0.470	0.638	0.001	n.s.
H4a: DL x Technostress -> IWB	-.061	1.560	0.119	–	Not supported
H4b: DL x Telepressure -> IWB	-.037	0.900	0.370	–	Not supported
H4c: DL x Role Stress -> IWB	-.012	0.310	0.756	–	Not supported

Note: N = 384; 10,000 bootstrap subsamples. DL = digital literacy. f^2 of 0.02, 0.15, 0.35 = small, medium, large. n.s. = not significant.

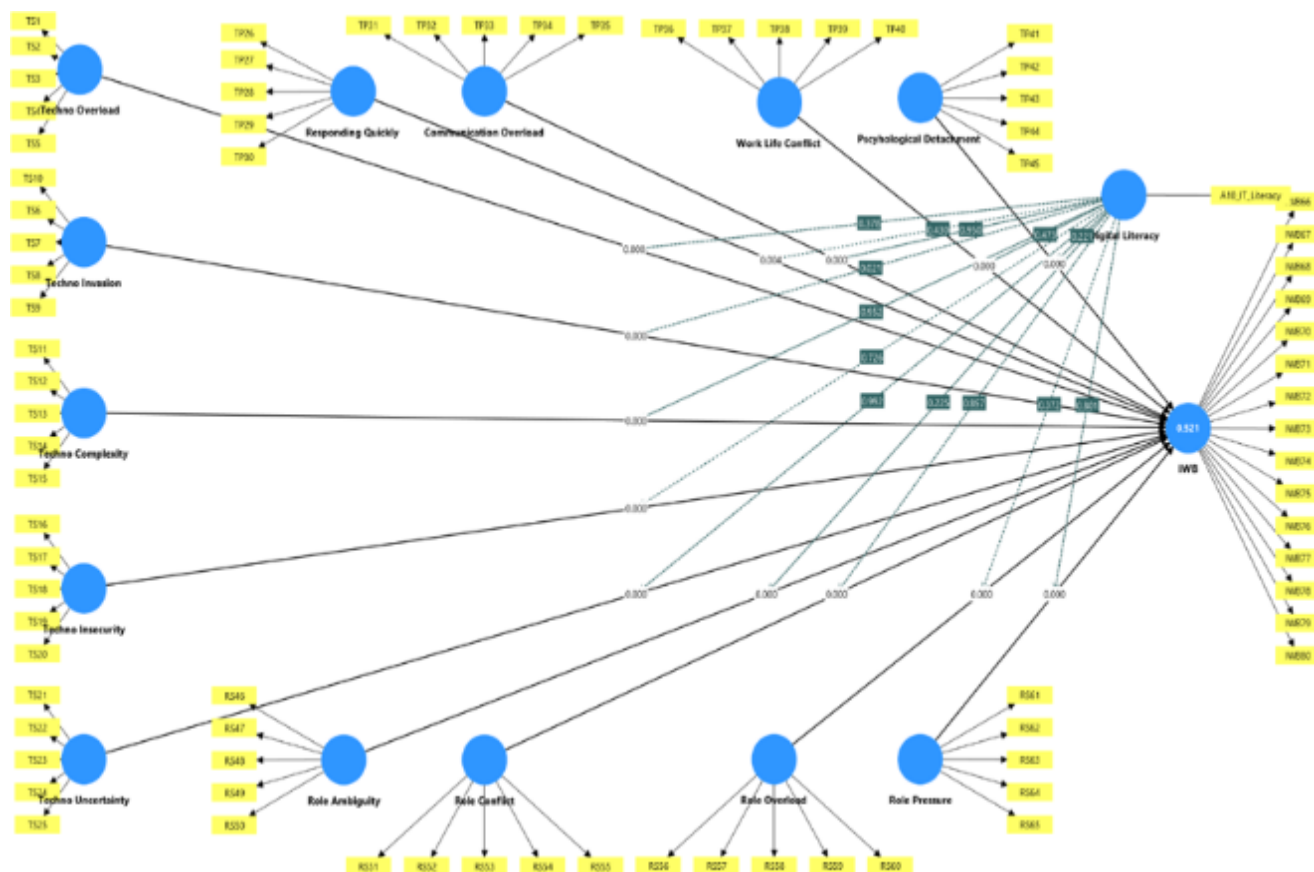


Figure 2 Structural Model – Path Coefficients

Moderator Testing

Three interaction terms (Table 7) were tested to examine the moderating role of digital literacy. None of them was significant: digital literacy $\times$ technostress ($\beta = -.061$, $p = 0.119$), digital literacy $\times$ telepressure ($\beta = -.037$, $p = 0.370$) and digital literacy $\times$ role stress ($\beta = -.012$, $p = 0.756$); all confidence intervals contained 0, and the interaction block did not contribute significantly to R^2 (0.011). Digital literacy also did not impact the direct effect ($\beta = -.018$, $p = 0.638$). At low, mean, and high levels of digital literacy, the negative impact of each of these stressors on IWB is significant and doesn't change in meaningful ways (Table 8); this is known as a conditional (simple-slope) effect. Thus, the hypothesis H4 was rejected.

Table 8

Conditional (Simple-Slope) Effects at Levels of Digital Literacy

Path -> IWB	β (Low DL)		β (Mean)		β (High DL)	
Technostress	-.360	***	-.420	***	-.481	***
Telepressure	-.306	***	-.343	***	-.380	***
Role Stress	-.379	***	-.391	***	-.403	***

Note: N = 384. Low/High DL = -1 SD / +1 SD of digital literacy. *** $p < 0.001$.

Discussion

Discussion

This study explored the influence of technostress, telepressure and role stress, as a second-order construct, on educator IWB, as well as whether digital literacy acts as a moderating variable in these relationships. The model had acceptable predictive relevance with 49.4% of variance explained by the model. Technostress had the most negative impact ($\beta = -.420$, $f^2 = 0.340$, a large effect) which aligns with prior research that demonstrates the negative impact of technostress on pedagogical innovation and online-teaching continuance (Bourlakis et al., 2023; Chou & Chou, 2021; Yang et al., 2025) and its formative weights of techno-complexity and techno-overload. Role stress also turned out to have a significant negative effect ($\beta = -.391$), which is in line with role theory and previous findings reported by Callista and Hastuti (2024) because role conflict and role ambiguity had a significant positive effect on role stress. The medium negative effect was for Telepressure ($\beta = -.343$), which is consistent with the argument that constant connectivity reduces the recovery innovation needed (Pfaffinger et al., 2022). Since the design is cross sectional, these relationships are considered associations, not cause and effect.

Contrary to expectations, digital literacy did not moderate any of the three relationships, nor did it have a direct effect on IWB, and thus (H4) was rejected. The impact of strain on innovation was found to be almost the same across the three groups of low, medium and high digital literacy. One possible reason for this is that we might have a digitally mature sample, as 63% rated their digital literacy as advanced or expert, and thus the buffering capacity of digital literacy may have been saturated such that there may not be much room through which it could affect the strain–innovation relationship (Czaja et al., 2006). The discovery is not optimistic that increasing the digital literacy of staff will ensure innovative capacity if the stressors are still present.

Theoretical and Practical Implications

Theoretically, the study combines three demand families in a single model based on the JD-R theory and defines each demand as a higher-order construct and empirically supports the non-buffering effect of the widely assumed personal resource, “digital literacy” on the strain innovation link in a digitally mature academic workforce, further clarifying the boundary conditions of the strain-impairment process. In practice, all three stressors have a negative impact on IWB and, here, digital literacy does not buffer the stressors, thus a reduction in the stressors is more important than up-skilling staff. Technostress is the highest contributor followed by techno-complexity and techno-overload; transparent technology-change roadmaps, dedicated training time, realistic workloads, and consolidation of digital platforms are the highest-leverage measures; role stress is addressed by role clarification; communication norms that protect recovery address telepressure. The cross-sectional nature of the evidence means that these recommendations are theoretically based extensions of the evidence that should be supported by intervention studies.

Limitations and Future Research Directions

Several limitations point to directions for future research. The cross-sectional design precludes causal inference and cannot rule out a reciprocal pathway in which more innovative educators adopt more technology and thus experience more strain; longitudinal or experimental designs are needed. All measures were self-reported although common method

variance was tested and found not to be a threat so IWB would benefit from supervisor or peer ratings. Digital literacy was measured with a single self-assessment item; a multi-item, behaviourally anchored measure may capture the construct more sensitively and could yet reveal moderation. The sample was confined to private universities in the Klang Valley, so generalisation to the public sector and other regions should be cautious. Finally, future work could model job resources such as institutional support and autonomy as buffers, test multi-group differences across disciplines and delivery modes, and examine mediators such as work engagement and emotional exhaustion.

Theoretical and Contextual Contributions

This study makes several important theoretical contributions to the existing literature. First, it extends the Job Demands-Resources (JD-R) model by simultaneously examining three distinct, yet interconnected job demands, namely technostress, telepressure, and role stress, within a single integrated framework. While previous studies have typically investigated these stressors independently, this study demonstrates their collective influence on innovative work behaviour and provides a more comprehensive understanding of how multiple forms of work-related strain affect innovation in digital work environments.

Second, the study contributes methodologically by conceptualising technostress, telepressure, and role stress as higher-order multidimensional constructs using a reflective-formative hierarchical component model in PLS-SEM. This approach provides a richer and more theoretically robust representation of workplace stressors than treating them as unidimensional constructs.

Third, the findings contribute to the growing body of literature on personal resources within the JD-R framework. Contrary to conventional assumptions, digital literacy did not moderate the negative effects of technostress, telepressure, and role stress on innovative work behaviour. This finding challenges the prevailing notion that stronger digital competencies automatically protect employees against technology-related strain. Instead, the results suggest that digital literacy may reach a threshold beyond which additional competencies provide limited buffering benefits. This extends understanding of the boundary conditions of personal resources within digitally mature work environments.

From a contextual perspective, this study contributes empirical evidence from Malaysian private higher education institutions, a setting that remains underrepresented in the innovative work behaviour and technostress literature. The rapid expansion of virtual learning environments and digital teaching technologies has significantly transformed academic work in Malaysia, particularly within private universities. The findings demonstrate that technology-related demands can undermine innovation among academics regardless of their levels of digital literacy. Consequently, the study provides valuable insights for policymakers, university administrators, and academic leaders seeking to balance digital transformation initiatives with employee well-being and innovation outcomes. By offering evidence from a Southeast Asian higher education context, the study enhances the geographical diversity of the literature and improves the generalisability of JD-R theory within digitally intensive educational environments.

Conclusion

This study examined the effects of technostress, telepressure, and role stress on innovative work behaviour among academic staff working in virtual learning environments in Malaysian private universities. Guided by the Job Demands-Resources (JD-R) model, the study conceptualised the three stressors as higher-order constructs and assessed their direct effects on innovative work behaviour while testing digital literacy as a moderating variable.

The findings revealed that technostress, telepressure, and role stress each exert a significant negative influence on innovative work behaviour, with technostress emerging as the strongest predictor. These results suggest that excessive technological demands, communication pressures, and role-related challenges reduce academics' capacity to generate, promote, and implement innovative ideas in teaching and learning activities. Contrary to expectations, digital literacy neither directly influenced innovative work behaviour nor moderated the relationships between the stressors and innovative work behaviour.

Overall, the study highlights that innovation among academics is influenced more by the reduction of workplace stressors than by improvements in digital competencies alone. As higher education institutions continue their digital transformation journey, managing technological and organisational demands remains essential for sustaining innovation and enhancing educational quality.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this study.

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