Available online at www.ijournalse.org

Emerging Science Journal

(ISSN: 2610-9182)

Vol. 9, No. 1, February, 2025

Unveiling the Decision-Making Process of Digital Transformation Adoption from a Behavioral-Cognitive Perspective: Mediating and Moderating Mechanisms

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Abstract

Although digital transformation (DT) is an unavoidable trend today, achieving successful DT presents numerous challenges. Problem-solving skills (PSS) and knowledge barriers in the digital age are among the most pressing issues. Given this premise, this research aims to unveil the "decision-making related to digital transformation adoption (DTDM)" via the cognitive processes and PSS. The study conducted an online survey with 516 current employees of Vietnamese enterprises to evaluate the measurement and structural models and to clarify the nexuses between low cognitive level (LCL), high cognitive level (HCL), PSS, and DTDM. The research results show that LCL, HCL, and PSS are positively associated with DTDM, with HCL and PSS mediating the relationship between LCL and DTDM. In addition, the study also pointed out the moderating role of creativity (CRT) in the association between LCL and DTDM. Consequently, the study makes significant practical and theoretical contributions to DT and helps address current bottlenecks related to the barriers to DT.

Keywords:

Digital Transformation;
Decision-Making; Problem-Solving Skills;
Low Cognitive Level;
High Cognitive Level; Creativity.

Article History:

Received:	29	October	2024
Revised:	14	January	2025
Accepted:	21	January	2025
Published:	01	February	2025

1- Introduction

Globalization and international economic integration are inevitable trends that all countries must confront, facing challenges and new opportunities [1]. Advances in science and technology coupled with the opening up of markets in developing countries have significantly changed the structure and operations of organisations in a variety of sectors [2]. While Industry 4.0 is no longer a novelty in developed countries, emerging countries are still in the process of transformation and adaptation, with a top priority on promoting economic development and enhancing competitiveness [3]. Digital transformation (DT) and innovation are two of the most important topics in the sustainable development of enterprises [4]. In such an emerging market, the Vietnamese government recognizes DT as a crucial national priority and explicitly states the goals for 2030, in which perception plays a decisive role in DT; in other words, DT is, first and foremost, cognitive change [5].

In parallel with the practical importance of DT in emerging economies, studies on DT have been conducted and have made significant contributions to the understanding of this topic [6-10]. Barriers in the digital age have received the most attention in current DT studies [7, 9, 11]. Kumar et al. [7] indicated that in-house technology skills and operational realities were directly and indirectly associated with digitalization adoption barriers, with readiness barriers as a

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DOI: http://dx.doi.org/10.28991/ESJ-2025-09-01-023

mediating factor. In line with this, Pandey et al. [9] found that lacking technical knowledge and skills was a barrier to adopting DT. Kallmuenzer et al. [11] also reaffirmed that DT today needed to take into account employees and the lack of necessary capacities and skills as critical barriers. Although the current knowledge and skill barriers of employees in the context of applying DT have been identified, current studies have not yet thoroughly addressed this research gap and clarified the role of employee cognition (thinking) prior to deciding to adopt DT [7, 12], as well as the relationship between employee cognition and their PSS [13].

On the other hand, the determinants of DTDM have also been of great interest to previous scholars [14-16]. By building theoretical models of DTDM through literature, previous studies still have certain similarities in factors affecting DT adoption, such as technology, organization, and environment [4, 17, 18]. On the other hand, Nguyen et al. [19] indicated that customer orientation, supplier cooperation, and employee IT skills were associated with digitalization strategy adoption via big data organizational culture (mediator) and leader commitment (moderator). Similarly, Chang & Octoyuda [14] found that learning agility was significantly correlated with adopting digital technology innovation via transformational leadership. Besides the contributions to the explanation of DTDM, the limitations of previous research on this topic are also highlighted. Chang & Octoyuda [14] argued that the cognitive domains leading to DTDM were insufficient and that other factors needed to be considered, such as "tolerance to failure, critical thinking, purpose orientation, conveying messages, acting ethically, and information gathering." Surprisingly, most previous studies that have taken this approach to DT adoption have not addressed employee cognitive processes, such as low and high cognitive levels [14, 20], or the role of PSS in the DM process that leads to DT adoption [13]. It is assumed that knowledge is necessary for employees in DT adoption [15]; however, how will the cognitive process take place under the impact of knowledge? Given this premise, exploring the connection between both low-level and high-level thinking and problem-solving abilities within the framework of DT adoption points out a significant research gap that should be considered.

Other research on DT adoption DM focused on the components of behavioral models and theories such as the technology acceptance model (TAM) [21, 22], the unified theory of acceptance and use of technology (UTAUT) [16, 23], etc. In this approach, previous studies have mainly considered DT adoption behaviour as a result of factors leading to behavioural intention; however, behavioural intention does not necessarily lead to the final decision, which may or may not be beneficial [24]. In other words, previous behavioural theories have been limited in their ability to clarify the cognitive processes individuals undergo when making decisions [24], particularly those that are beneficial and require significant mental effort [25]. Notably, the elements in the UTAUT model, such as "performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC), and social influences (SI)," cannot address the current barriers (such as technology skills and knowledge) in the process of forming DTDM [16, 26]. Similarly, the main components of TAM, such as "perceived usefulness (PU) and perceived ease of use (PEOU)," cannot address individual skill barriers in the context of DT adoption [21, 22]. These findings point to theoretical gaps in current research models that approach DTDM through behavioral models and theories such as TAM and UTAUT.

Although researchers have demonstrated the critical role of thinking ability (TA) in the DM process, it is still limited in the context of DT adoption [12]. Current research on DM from a cognitive perspective has not yet shown consistent results [24, 27]. For example, TA was not directly associated with DM, while indirectly affecting DM via PSS in the study of Tran et al. [27]. In addition, Tran et al. [27] indicated that creativity positively impacted individual DM. In contrast, TA was found to be the main factor that caused changes in decision-making under the influences of emotional intelligence in the study of Tran & Van Pham [24]. To better understand the individual's cognitive processes leading to DM, especially in the field of DT, it is necessary to differentiate the level of cognition (low or high) that is appropriate to the individual's PSS [13]. Given such a premise, managers can tailor training in alignment with the individual's own TA and strengthen the employee's PSS, shedding light on DT adoption [2]. "Creativity" is regarded as "a crucial factor in fostering sustainable production and innovation in operational activities" [28]. Nevertheless, "evaluating" is considered the highest level of cognition for making decisions, while "creating" refers to new ideas or innovations in operation or implementation [29, 30]. In this case, the intriguing inquiry is whether creativity is linked to DTDM.

It can be concluded that the research gaps discussed above are associated with the cognitive processes prior to deciding to adopt DT, as well as the link between cognition and PSS in the current context. To address the above research gaps, this study aims to explore the associations between low cognitive level (LCL), high cognitive level (HCL), and decision-making related to digital transformation adoption (DTDM), with problem-solving skills (PSS) as a mediator and creativity (CRT) as a moderator. In alignment with this research approach, the role of TA (including LCL and HCL) will be clarified in relation to PSS, shedding light on DTDM. Furthermore, CRT is expected to moderate the associations between LCL and DM, HCL and DM, and PSS and DM, highlighting not only the direct impact of CRT on DM but also its moderating effects on the relationships among LCL and DM, HCL and DM, and PSS and DM. As a result, the research results are expected to contribute significantly to the understanding of DT decisions of enterprises in emerging markets, highlighting practical and theoretical implications in the context of the 4.0 industrial revolution.

2- Literature Review and Hypotheses

2-1- Literature Review

The literature has significantly highlighted the term "digital transformation" in terms of its definition and context [10, 31-33]. Kim et al. [34] defined DT as "a change caused by digital technologies in not only firms but also in the overall economy and society," while Gong & Ribiere [35] mentioned DT as "a fundamental process that involves the innovative use of digital technology, as well as the strategic leverage of critical resources and competencies, to significantly improve an entity and redefine what it offers for its stakeholders.". Due to the diversity of DT in both definition and context, Kao et al. [36] redefined and proposed four key attributes: (1) DT is "not simply about improving competitiveness and sustainable development but is a data-driven strategy," (2) DT is "the adoption of digital technology to collect and analyze data in order to improve internal and external corporate operations, as well as DM processes," (3) DT is "a continuous process that creates ecosystems, innovates enterprise models, and transforms organizational culture, supply chains, propositions, and customer experiences," and (4) DT is "to improve enterprise business performance". In line with the above definitions, DT adoption can be defined as the process by which organizations integrate digital technology into their operations, business models, and customer interactions to improve performance and develop new value propositions [36, 37].

Literature shows that recent research models on DT adoption are mainly built according to two approaches: (1) developing research models based on previous behavioral theoretical models and (2) developing research models based on the research context. Accordingly, TAM, UTAUT, and UTAUT2 are the three main theories applied to explain DT adoption behavior [16, 22, 23, 26]. In a study by Gündoğan & Keçeci [22], perceived usefulness (PU) and perceived ease of use (PEOU) were positively associated with behavioral intention, shedding light on DT adoption behavior. Similarly, Kwarteng et al. [16] indicated that PU, PEOU, affordability, and user device availability were positively associated with behavioural intention to adopt DT, leading to DT adoption behaviour. In addition, digital broadcast availability, digital literacy, and intention to use the digital device were shown to have a positive relationship with DT adoption behavior [16]. Most previous behavioral theory-based studies have suggested that behavioral intention is the determining factor leading to DT adoption, while the role of pre-adoption cognition is rather weak, although perceptions of usefulness and ease of use are still mentioned [22, 23, 38]. As stated, the decision to adopt DT requires more than just the perception of usefulness and ease of use or the intention to adopt; it also requires both technology skills and knowledge [7, 13]. This highlights the limitations of behavioral theories in explaining DTDM in the current context.

In the remaining research approach, contextual factors and barriers affecting the decision to adopt DT have been mostly recommended by previous scholars [6, 10, 14, 19, 39]. Technology, organization, and environment are regarded as the three main factors affecting DT adoption [4, 6, 17, 18, 32, 40, 41], while digital knowledge and technology skills are the main barriers highlighted by previous studies [7, 9, 11, 42]. In addition, Al-Alawi et al. [20] emphasized that funding, infrastructure, technical support, digital skills or talents, organizational culture, employee engagement, and support from top management impact the adoption of DT in HRM. Previous studies have shed light on contextual factors and current barriers related to DT adoption; however, the role of pre-DT adoption thinking, or the cognitive abilities associated with PSS, has not been addressed in any studies [12].

Based on the findings in the literature, the current research gaps are related to the cognition prior to adopting DT [12] and its impact on the barriers - employee PSS in the DM process. To address them, this study approaches the cognitive processes before adopting DT by examining the impacts of LCL on HCL, as well as on PSS and DTDM. LCL is related to the ability to remember and understand the contents of DT adoption, while HCL is associated with the ability to apply, analyze, and evaluate [43]. Such as low cognitive levels, individuals need to be provided with relevant information to help them remember and understand easily instead of focusing on new ideas immediately [24]. Stemming from the taxonomy of educational objectives of Bloom [29] and the TED model of Tran and Van Pham [24], scales of low and high levels of thinking were constructed, which allow clarifying the cognitive processes of employees, leading to the decision to adopt DT. Besides, CRT is considered the highest level of individual thinking, encompassing abilities such as generating, assembling, designing, and creating, which are related to DT adoption [43]. According to Tran et al. [13], lower levels of cognition serve as the foundation for higher levels of cognition, and cognition leads to decisions primarily at the evaluative level rather than at the highest level of thinking (CRT) [29]. This study, therefore, approaches the DTDM via a cognitive perspective combined with PSS [27] and the moderating role of CRT on relationships such as LCL and DTDM, HCL and DTDM, as well as PSS and DTDM.

2-2- Developing Hypotheses

The cognitive processes that lead to DM have been clarified in previous studies across various contexts and fields [24, 44-46]. Recent studies on DT indicate that PU and PEOU are often mentioned, with the indicators of these two factors considered to be at a low cognitive level, such as knowing or recognizing [16, 22]. Similarly, T. L. Nguyen et al.

[2] reaffirmed that the cognitive level of employees progressed from recognizing to applying at the enterprise level. On the other hand, critical thinking refers to a high level of individual cognition that leads to DM; however, most of these studies have focused on the educational field rather than applying it to business decisions [47, 48]. Therefore, examining the effects of LCL and HCL on the decision to adopt DT is an important finding that needs to be clarified.

H1: There is a positive impact of LCL on the decision to adopt DT;

H2: There is a positive impact of HCL on the decision to adopt DT;

According to Bloom [29], the cognitive process is divided into six dimensions: remembering, understanding, applying, analyzing, evaluating, and creating. Corresponding to this process, in order to achieve higher levels of cognition, lower levels must first be satisfied. For example, to reach the level of "applying," two lower levels, such as "remembering" and "understanding," must be met [29]. According to Tran et al. [13], LCL is considered to be the foundation of HCL and is positively related to PSS in the context of DT. In addition, Tran et al. [27] argued that improving individuals' PSS also enhances their DM ability.

H3: *There is a positive impact of LCL on HCL in the context of DT adoption;*

H4: There is a positive impact of LCL on PSS in the context of DT adoption;

H5: There is a positive impact of HCL on PSS in the context of DT adoption;

In addition, PSS is defined as "the ability to solve problems logically, including finding information, analyzing situations to identify problems and develop alternative courses of action, generating alternative courses of action for desired or expected outcomes, and choosing and putting into action a suitable plan of action [13]. PSS has been found to be positively related to DM in previous research [27].

H6: There is a positive impact of PSS on DM in the context of DT adoption;

Creating is considered the highest level of cognition among the six dimensions of the cognitive process [29]. Qudrat-Ullah [30] found that CRT and DM were mutually supportive rather than separate processes. In some cases, creativity enhances DM by increasing the number of viable options [27], and conversely, DM enhances creativity through feedback [30]. Research by Qudrat-Ullah [30] still suggests that the DM process revolves around the following steps: problem identification, idea generation, idea selection, idea development, idea implementation, and monitoring and evaluation. Clearly, evaluation is the highest level of cognition in the entire decision-making process rather than CRT. Examining the moderating role of CRT in the relationships leading to DM will shed light on the DM process in the context of DT adoption.

H7a: Creativity moderates the relationship between LCL and DM in the context of DT adoption;

H7b: Creativity moderates the relationship between HCL and DM in the context of DT adoption;

H7c: Creativity moderates the relationship between PSS and DM in the context of DT adoption;

The conceptual model is presented in Figure 1.

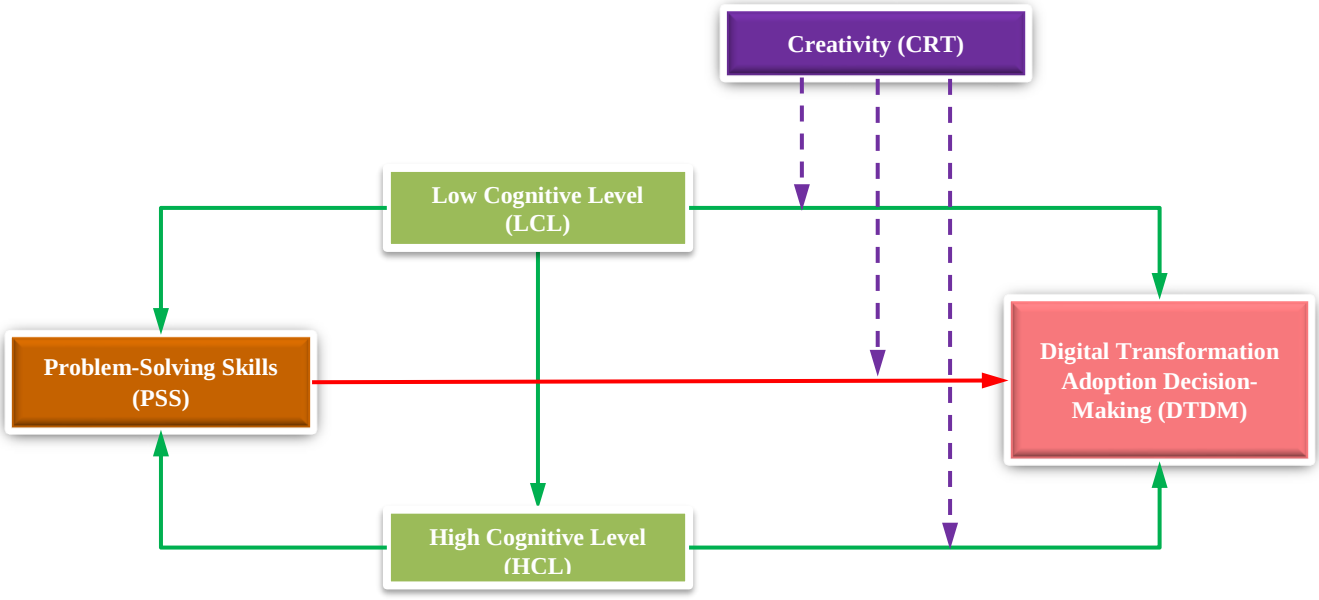

Figure 1. The conceptual model

3- Research Methodology

A deduction approach and a mixed method were applied in this study, including qualitative and quantitative research. The proposed research design is presented in Figure 2.

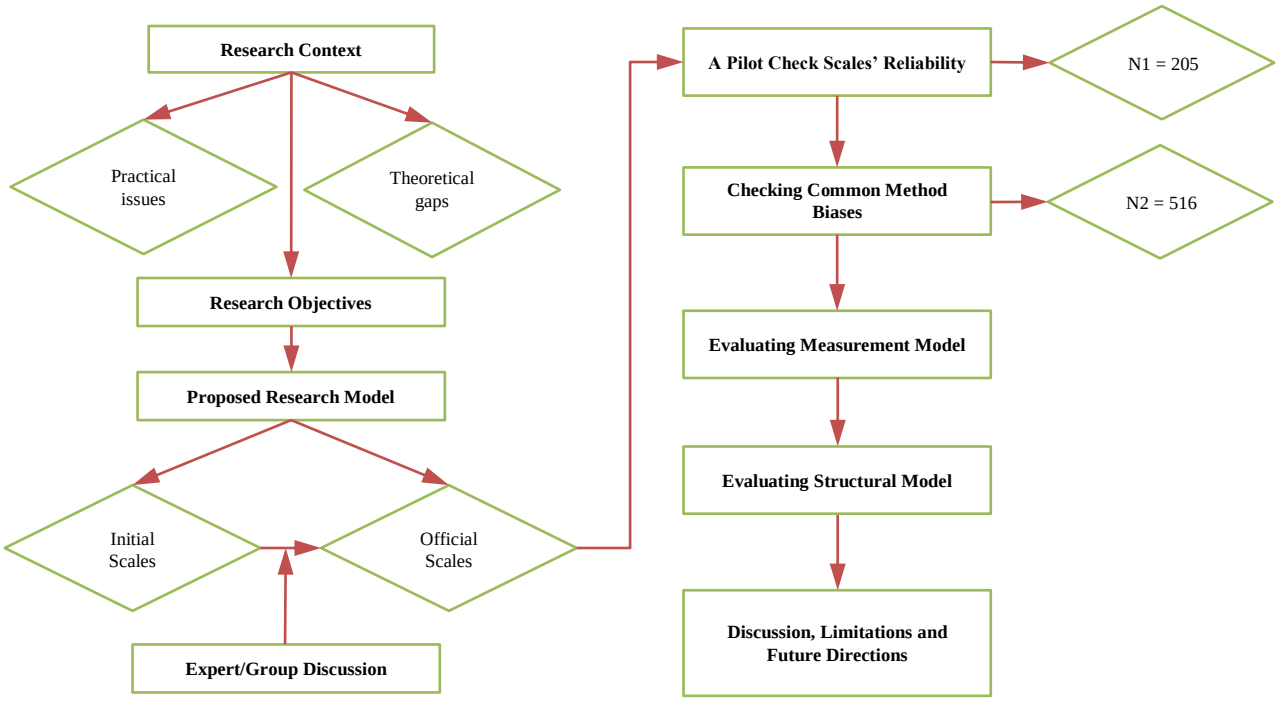

Figure 2. The research design

3-1- Data Collection and Measurement Instrument

Via the convenient sampling method, the participants are current employees of enterprises in South Vietnam. Respondents were mostly young workers aged 18 to 40, answering the survey via online survey (Google Forms). The sample size in this study was based on the 10-time rule following the instructions of Hair et al. [49]. Despite being an online survey, the study attracted more than 800 participants with the support of business managers in sharing survey information and providing guidance to respondents. As a result, the study collected 516 valid responses and conducted further analysis. The demographic results of the respondents are summarized in Table 1. Similarly, the measurement scales are presented in Table 2.

Table 1. Samples' characteristics

Variables	Description	N = 516	%
Gender	Female	298	57.75
	Male	218	42.25
Age	18-30 years	331	64.1
	31-40 years	149	28.9
	41-50 years	29	5.6
	>50 years	7	1.4
Education	Vocational intermediate	172	33.3
	College	112	21.7
	University	200	38.8
	Postgraduate	32	6.2
Job seniority	1 – 5 years	151	29.3
	6 – 10 years	107	20.7
	11 – 20 years	236	45.7
	> 20 years	22	4.3

Table 2. Measurement scales in the current study

Variables	Indicators	Cronbach's alpha (α)	References
	Low cognitive level (LCL)	**0.845**	Bloom [29], Munzenmaier & Rubin [43], and Tran and Pham [24]
LCL1	I can list the issues related to DT adoption that I have to address shortly;	0.844	
LCL2	I remember and can recite recent DT-related events.	0.835	
LCL3	I understand DT issues and recognize the context of situations that arise;	0.806	
LCL4	I recognize and solve DT problems in life well based on available knowledge;	0.814	
LCL5	I quickly identified the issues related to DT adoption that needed to be addressed first;	0.809	
LCL6	I clearly define the objectives to be reached when developing the action plan for adopting DT.	0.808	
	High cognitive level (HCL)	**0.888**	Bloom [29], Munzenmaier & Rubin [43], and Tran & Pham [24]
HCL1	I believe in clarifying the issues involved in adopting digital transformation;	0.878	
HCL2	When dealing with challenging DT adoption difficulties, I can reason deeply and clearly;	0.856	
HCL3	I objectively provide information about events and phenomena related to DT;	0.874	
HCL4	I can answer questions related to DT adoption with high logic;	0.845	
HCL5	I can think logically when faced with the difficult problems of DT adoption.	0.862	
	Problem-solving skills (PSS)	**0.908**	Tran et al. [27] and Tran et al. [13]
PSS1	I can differentiate clearly between what is and is not relevant to DT adoption in the circumstance under discussion;	0.893	
PSS2	When analysing the situation related to DT adoption, I can detect the main causes of the issues;	0.885	
PSS3	I am constantly seeking new methods to approach the problem of DT adoption;	0.875	
PSS4	I can thoroughly analyse and assess choices while offering solutions for DT adoption;	0.888	
PSS5	When selecting a solution to adopt DT, I can judge the consequences/ opportunities.	0.896	
	Creativity (CRT)	**0.929**	Bloom [29], Munzenmaier & Rubin [43], and Tran & Pham [24]
CRT1	I am constantly cognisant of how to apply my knowledge and experience to real-life circumstances involving DT adoption;	0.920	
CRT2	I am flexible and creative in solving problems related to DT adoption;	0.917	
CRT3	I can assemble options when making a DT adoption decision;	0.922	
CRT4	I am swift and can manage complex problems involving DT adoption;	0.916	
CRT5	I tend to make decisions regarding DT adoption based on reason;	0.928	
CRT6	I can assess and select effective solutions for DT adoption;	0.916	
CRT7	I'm getting faster at tackling complex DT difficulties;	0.925	
CRT8	I frequently arrive at precise conclusions when dealing with complex DT adoption difficulties.	0.916	
	Digital transformation adoption decision-making (DTDM)	**0.950**	Tran & Pham [24]
DTDM1	I chose to adopt DT because of the benefits it would offer to my current profession and life;	0.945	
DTDM2	I chose to adopt DT because I identified the long-term benefits for my future profession and life;	0.940	
DTDM3	I chose to adopt DT because I am interested in exploring technological advances;	0.944	
DTDM4	Adopt DT since it helps me accomplish my work more rapidly and successfully;	0.939	
DTDM5	Adopt DT allows me to stay current with current trends;	0.945	
DTDM6	Adopt DT allows me to expand my knowledge and abilities;	0.944	
DTDM7	I chose to adopt DT as it provided various shared values to society;	0.942	
DTDM8	I'll encourage colleagues to participate in DT projects with me.	0.944	

3-2-Analytic Methods

According to the research design (Figure 2), after having official measurement scales from the qualitative research phase, quantitative research was conducted through the following steps: testing official scales' reliability with a pilot sample of 205, checking for common errors (multicollinearity) such as VIF indexes with an official sample of 516, analyzing the measurement and structure models.

The results of testing official scales' reliability with a pilot sample of 205 were satisfied when all Cronbach's alpha coefficients were greater than 0.6 [49]. In addition, multicollinearity did not occur in this study because all VIF values were less than 3.3 [49]. In the next step, the measurement model was analyzed according to the instructions of Hair Jr.

et al. [49] in the following criteria: convergent validity (outer loading ≥ 0.708; AVE ≥ 0.5), composite reliability (CR ≥ 0.6 or α ≥ 0.7), and discriminant validity (Fornell-Larcker or Heterotrait–Monotrait ratio). Finally, the structural model will be evaluated to demonstrate the path relationships and answer the initial hypotheses.

4- Research Results

4-1- Measurement Model

Table 3 shows the results of convergent validity (CV) and composite reliability (CR) of the measurement model. The CR was satisfied due to CR_{min} = 0.869 and α_{min} = 0.798. The CV was not satisfied since the outer loadings of LCL1, LCL2, HCL1, and CRT5 were smaller than 0.708. Although all AVE indexes in this model were higher than 0.5, these variables (LCL1, LCL2, HCL1, and CRT5) were removed to ensure the CV.

Table 3. Convergent validity and composite reliability

Items	Code	Mean	Loadings	α	CR	AVE
Low cognitive level	LCL1	3.83	0.568	0.801	0.882	0.627
	LCL2	3.48	0.631			
	LCL3	3.66	0.761			
	LCL4	3.97	0.755			
	LCL5	3.86	0.823			
	LCL6	3.79	0.825			
High cognitive level	HCL1	3.46	0.697	0.798	0.869	0.624
	HCL2	3.64	0.784			
	HCL3	3.95	0.751			
	HCL4	3.35	0.799			
	HCL5	3.64	0.823			
Problem-solving skills	PSS1	3.74	0.757	0.833	0.882	0.599
	PSS2	3.91	0.790			
	PSS3	3.78	0.791			
	PSS4	3.94	0.775			
	PSS5	3.88	0.758			
Creativity	CRT1	3.63	0.772	0.886	0.910	0.592
	CRT2	3.45	0.802			
	CRT3	3.60	0.749			
	CRT4	3.35	0.808			
	CRT5	3.68	0.655			
	CRT6	3.60	0.775			
	CRT7	3.34	0.720			
	CRT8	3.26	0.756			
Digital transformation adoption decision-making	DTDM1	3.90	0.817	0.920	0.934	0.641
	DTDM2	3.96	0.846			
	DTDM3	3.91	0.790			
	DTDM4	4.00	0.851			
	DTDM5	4.02	0.763			
	DTDM6	3.97	0.785			
	DTDM7	3.96	0.787			
	DTDM8	3.87	0.758			

After ensuring the CV and CR, the discriminant validity (DV) was evaluated. The Fornell-Larcker criteria were applied in this study [24]. According to the results in Table 4, every latent variable's square root of AVE is higher than the correlation between it and every other latent variable. Hence, the DV was confirmed. In addition, the SRMR of this study (Table 5) is smaller than 0.08; therefore, the model fit was confirmed [49].

Table 4. The Fornell-Larcker criteria results

Construct	CRT	DTDM	HCL	LCL	PSS
CRT	**0.769**				
DTDM	0.482	**0.800**			
HCL	0.680	0.552	**0.790**		
LCL	0.646	0.596	0.688	**0.792**	
PSS	0.701	0.622	0.719	0.751	**0.774**

Table 5. Structural model testing

Hypotheses	Associations	P.C	S.D	T.S	P	Bias	2.5%	97.5%	Results
H1	LCL → DTDM	0.296	0.054	5.501	0.000	0.002	0.188	0.400	AC
H2	HCL → DTDM	0.119	0.055	2.160	0.031	-0.003	0.013	0.230	AC
H3	LCL → HCL	0.688	0.032	21.653	0.000	-0.000	0.620	0.746	AC
H4	LCL → PSS	0.487	0.042	11.481	0.000	-0.000	0.401	0.567	AC
H5	HCL → PSS	0.384	0.043	8.855	0.000	0.001	0.297	0.470	AC
H6	PSS → DTDM	0.330	0.060	5.535	0.000	0.002	0.207	0.444	AC

Note: P.C = Path coefficient, S.D = Standard deviation; T.S = T statistics, R2DTDM = 0.442, R2HCL = 0.474, R2PSS = 0.641, SRMR = 0.054 < 0.08.

4-2- Structural Model

The direct effects of the structural model are presented in Table 5 and Figure 3. As initially expected, the nexuses between cognitive ability, PSS, and DTDM were supported with a significance of 5%. In line with this, the hypotheses (H1 → H6) were accepted, and the positive effects of LCL on HCL (β = 0.688), PSS (β = 0.487), and DTDM (β = 0.296) were confirmed. Similarly, the positive influences of HCL on PSS (β = 0.384) and DTDM (β = 0.119) were confirmed. Lastly, the positive impact of PSS on DTDM was also confirmed (β = 0.330). Furthermore, the confidence intervals from 2.5% to 97.5% all have values that do not pass through 0; therefore, the nexuses of all relationships in this model were significant [49].

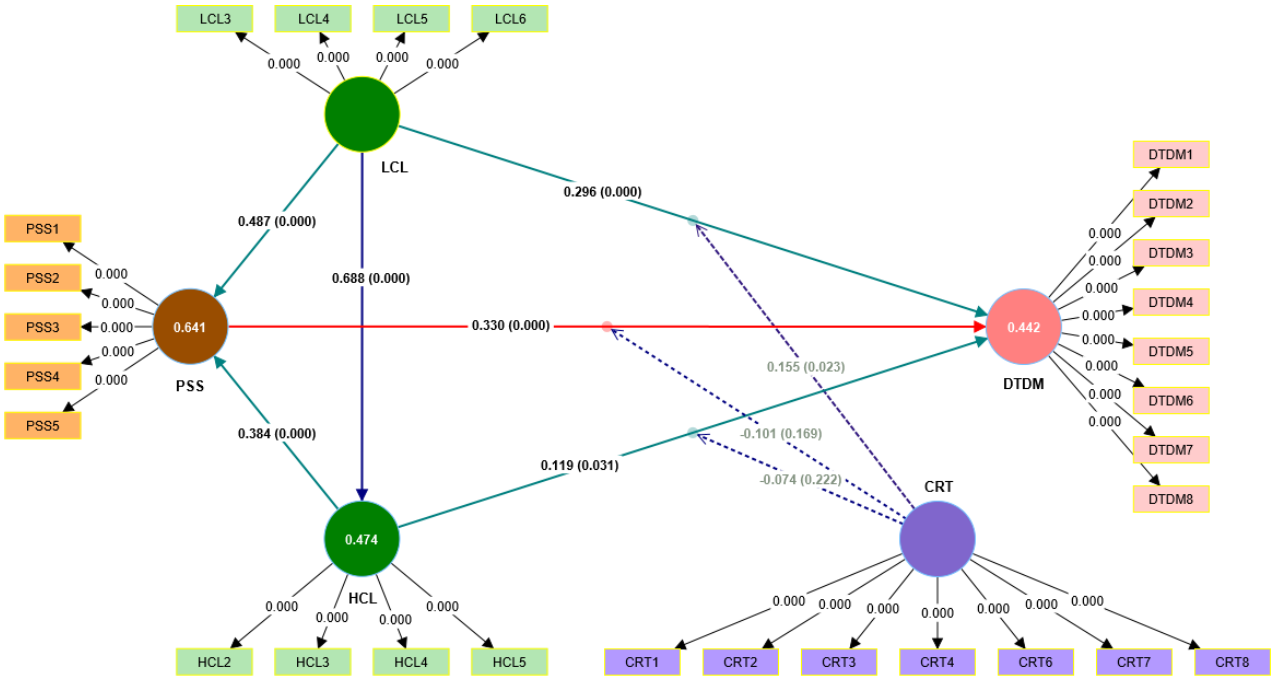

Figure 3. Coefficient paths of the conceptual model

Table 6 and Figure 4 show the results of the mediating and moderating mechanisms in the conceptual model of DTDM. The results demonstrated the mediating roles of HCL and PSS in the DTDM process under the influence of LCL with a significance of 5% (β= 0.087, p < 0.05). HCL mediated the nexuses between LCL and PSS (β = 0.082, p < 0.05), and between LCL and PSS (β = 0.264, p < 0.01). Similarly, PSS mediated the correlations between LCL and DTDM (β = 0.160, p < 0.01), and between HCL and DTDM (β = 0.127, p < 0.01).

Table 6. Mediating and moderating effects

	Associations	P.C	S.D	T.S	P	Bias	2.5%	97.5%	Results
	Mediating effects								
	LCL → HCL→ DTDM	0.082	0.038	2.163	0.031	-0.002	0.010	0.158	AC
	LCL → PSS → DTDM	0.160	0.033	4.883	0.000	0.001	0.100	0.231	AC
	HCL → PSS → DTDM	0.127	0.027	4.674	0.000	0.001	0.078	0.184	AC
	LCL → HCL → PSS	0.264	0.032	8.320	0.000	0.000	0.204	0.331	AC
	LCL → HCL → PSS → DTDM	0.087	0.019	4.580	0.000	0.000	0.054	0.127	AC
	Moderating effects								
H7a	CRT x LCL → DTDM	0.155	0.068	2.272	0.023	0.003	0.032	0.298	AC
H7b	CRT x HCL → DTDM	-0.074	0.060	1.221	0.222	-0.001	-0.197	0.039	RJ
H7c	CRT x PSS → DTDM	-0.101	0.073	1.377	0.169	-0.001	-0.245	0.042	RJ
	CRT → DTDM	-0.015	0.056	0.265	0.791	0.001	-0.123	0.096	RJ

Note: P.C = Path coefficient, S.D = Standard deviation; T.S = T statistics, AC = Accepted, RJ = Rejected;

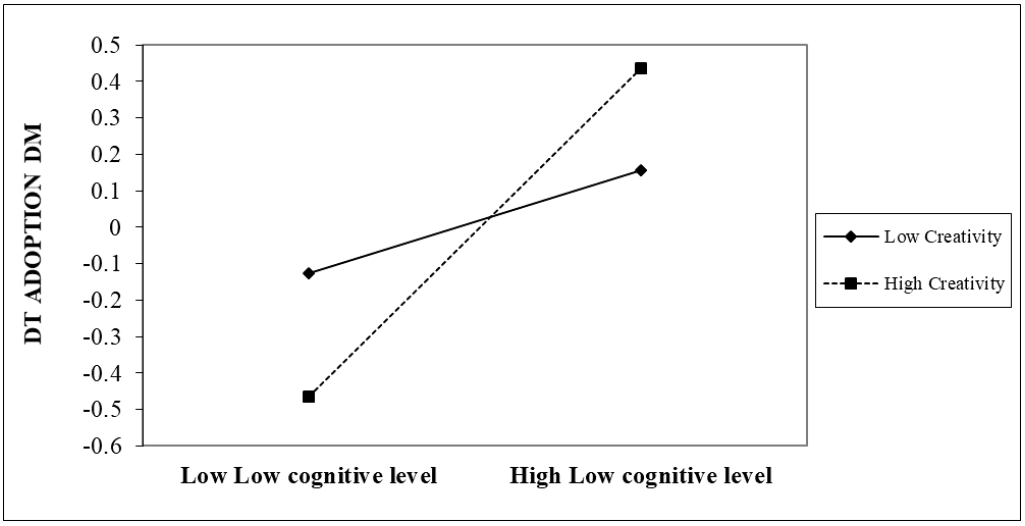

Figure 4. The moderating impact of CRT on the nexus of LCL and DTDM

In addition, the moderating role of CRT is also clarified in the nexus between LCL and DTDM (β = 0.155, p < 0.05), while it is not significant for the nexuses of HCL→ DTDM and PSS → DTDM (p > 0.05). Hence, H7a was supported, while H7b and H7c were not supported. This result shows that CRT has a positive impact on the relationship between LCL and DTDM, elucidating the moderating role of CRT in the context of DT adoption.

5- Discussion

As mentioned, DT is a key and top-priority objective in emerging countries such as Vietnam [3]. The main barriers come from staff knowledge and skills in the context of DT adoption [42], while employee cognition is the key to overcoming the above ones [13]. The research findings have revealed the cognitive processes in forming PSS and DTDM that no research has done before. The research also succeeds in conceptualizing a holistic model of the nexuses between cognition, PSS, and DM in the context of DT adoption. When the majority of the hypotheses were accepted and the study findings aligned with the original hypotheses, this demonstrated the direct correlation and mutual complementarity between human cognition, PSS, and DM. The research results are critical findings in formulating policies, guidelines, and roadmaps to address current barriers to skills and knowledge acquisition in the current context.

Regarding the positive effects of LCL on DTDM, HCL, and PSS (H1, H3, and H4), research shows the great importance of LCL (including remembering, understanding, and identifying DT adoption issues) in forming HCL (=0.688, p < 0.01), PSS (= 0.487, p < 0.01), and DTDM (= 0.296, p < 0.01). Notably, LCL is the foundation for individuals to achieve higher levels in the cognitive process (applying, analyzing, and evaluating) and is consistent with previous research findings of Tran et al. [13] and Bloom [29]. Additionally, this finding demonstrates that when individuals reach a certain level of cognition—such as recognizing, remembering, and understanding—PSS and DTDM are enhanced and developed. This result responds to the shortcomings of previous studies, such as Tran et al. [27] and Tran & Pham [24], which found that cognitive competency had an impact on DM or PSS while not clarifying whether the level of cognition was low or high.

In terms of the nexuses between HCL, PSS, and DTDM (H2 and H5), HCL was positively associated with not only DTDM (= 0.119, $p < 0.05$) but also PSS (= 0.384, $p < 0.01$). Despite having a positive impact on DTDM, HCL's effect is slightly weaker than LCL's. On the contrary, HCL has a significant positive relationship with PSS. This shows that HCL also plays a critical role in forming PSS. According to Bransford and Stein [50], the five steps of problem-solving include: "identify the problem, define the problem, explore possible strategies, act on the strategies, and look back and evaluate the effects.". It can be concluded that, in the present study, the author once again demonstrates and reproduces the uniqueness of the cognitive process and the views of previous scholars on problem-solving skills. Specifically, "identify the problem, define the problem, explore possible strategies" is considered a lower cognitive process (LCL), and "act on the strategies, and look back and evaluate the effects" is a higher cognitive process (HCL). These findings align with the research results of Tran et al. [13] regarding the relationship between TA and PSS. Additionally, the positive influences of LCL and HCL on DTDM represent unique findings that clarify the individual cognitive process, as previous studies on DT have rarely addressed this [16, 26]. Notably, the significant finding concerning the impact of HCL on DTDM is a strong response to the call by Chang & Octoyuda [14] regarding the influence of other cognitive factors, such as critical thinking, on DTDM.

Related to the nexus between PSS and DTDM (H6), PSS has a positive effect on DTDM ($\beta = 0.330$, $p < 0.01$), and this effect is stronger than that of both LCL and HCL on DTDM. This result demonstrates that PSS is the most important factor in the formation of DTDM and reaffirms the similarity with previous studies on PSS and DTDM [13, 27, 30]. This study is also a response to previous studies on employee skill barriers in the context of the digital age [7, 42], not only in terms of relevance but also as a premise for building strategies and policies to improve the PSS of employees in the organization.

The mediating effects of this study are notable. The research results show that HCL mediates the effects of LCL on PSS ($\beta_{LCL \rightarrow HCL \rightarrow PSS} = 0.264$, $p < 0.05$) and DTDM ($\beta_{LCL \rightarrow HCL \rightarrow DTDM} = 0.082$, $p < 0.05$). Similarly, PSS mediates the impacts of both LCL and HCL on DTDM ($\beta_{LCL \rightarrow PSS \rightarrow DTDM} = 0.160$, $\beta_{HCL \rightarrow PSS \rightarrow DTDM} = 0.127$, $p < 0.05$). These findings suggest that PSS is the catalyst for DTDM formation under the influence of LCL, although HCL also mediates a similar, albeit much weaker, relationship. It can be inferred that PSS play a crucial role in how cognition influences DTDM in the digital age. By improving cognitive activities, organizations can enhance employees' PSS, which in turn facilitates their decision to embrace DT. These findings reaffirm the mediating role of PSS in the formation of DTDM and are consistent with the results of Tran et al. [27]. The major difference in this study's results compared to previous findings is that the cognitive domains (LCL and HCL) are clarified, and they have an impact on DM through PSS [14, 24].

In line with the moderating effect of CRT on the nexus between LCL and DTDM (H7a), this is a critical and relatively novel finding compared to previous studies ($\beta_{CRT \times LCL \rightarrow DTDM} = 0.155$, $p < 0.05$). Qudrat-Ullah [30] indicated that "creativity and DM are not independent processes but are related and interdependent". Similar to this view, in a pilot study of Tran et al. [27] on students' decision to participate in extracurricular activities in the field of supply chain, it was found that creativity has a direct positive relationship to DM. As stated, "evaluation is the highest level of cognition in the entire decision-making process rather than creativity", and our current research results have proven this statement ($\beta_{CRT \rightarrow DTCM} = -0.015$, $p > 0.05$). Thus, the findings of this study differed from those of prior investigations on the link between CRT and DM [27, 30]. We believe that this distinction arises specifically in the context of the study, as the decision to apply DT is related to compliance with techniques that ensure operational correctness rather than subjective activities (such as the decision to participate in extracurricular activities) [27]. Our study found that CRT positively moderated the relationship between LCL and DTDM rather than indicating a direct relationship.

Theoretically, the study contributes to DM theory with a new approach instead of applying previous behavioral theories, such as TAM, UTAUT, UTAUT2, etc., to explain the process of forming DTDM. In this approach, research allows stakeholders to explain how individuals or employees absorb information and go through cognitive processes to form PSS and DTDM, while previous behavioral theories mainly consider DM through behavioral intentions [11, 22, 23, 26]. Although many other scientific disciplines have attempted to explain cognitive mechanisms, the behavioral field hides human cognitive properties under the umbrella of psychology [51]. Behavioral psychology theories view cognition as an attribute of the psyche [51]. Hence, we need to return human cognition to its rightful place in the study of behavior; that is, psychology is merely a manifestation of a cognitive state, not cognition itself, which is an attribute of psychology [37]. The results of this study also reaffirm the levels of cognition in individual DM and decipher the relationship between CRT and DM in the context of DT adoption.

Practically, this study contributes greatly to the central objectives of emerging countries, especially in the DT phase. According to Siebel [52], the current level of DT can be divided into three levels: digital interface, modular DT, and digital environment. However, barriers still revolve around employee knowledge and skills in the digital context if we exclude objective barriers that are difficult for individuals to implement. This research enables stakeholders to leverage and address knowledge and skills barriers through employee cognitive transformation. Clarifying the level of awareness of employees in the process of forming PSS and DTDM allows managers and policymakers to develop programs and content that are appropriate to the cognitive levels of employees, as well as what level of cognition they need to achieve in order to improve their skills and apply DT. In addition, the study also shows the negative and positive aspects of creativity. Although creativity is necessary for operational activities in certain contexts, its appropriateness must be considered. Hence, creativity should exist within an allowed framework rather than being completely unrestricted under any circumstances.

6- Conclusion

As mentioned, DT is an inevitable trend in emerging countries today. However, the DT process faces certain barriers. This study has successfully modeled the DTDM and has proposed implications to address the current barriers related to cognitive processes before applying DT, as well as the relationship between TA and skills in the digital age. These results have addressed the objectives set in the current context, clarifying how individuals perceive and develop PSS, as well as their impact on the application of DT. This study also offers a premise for future studies to approach DM from a cognitive perspective instead of approaching it from a behavioral psychology perspective, which has certain limitations in explaining behavior through intention. In addition, the study highlights the role of creativity in the relationship between LCL and DTDM, reaffirming findings from related studies in the behavioral field. Although this study has met the analytical requirements regarding sample size, it is necessary to expand the sample size in the future to confirm its relevance and overall representativeness.

In addition to its theoretical and practical contributions, the study has several drawbacks. Although the study generalized the cognitive process in the formation of PSS and DTDM, the study did not consider the temporary emotional factors before the impact of leadership views or exposure to information about DT adoption. This opens up a new direction of research in the future with great potential; for example, between temporary emotions and personal cognition, what will happen when deciding to apply DT? In addition, this is a cognitive and intense study; the questions are relatively abstract, which can easily confuse respondents, and the research results may not be the best. Future studies should combine online and direct surveys and then compare the research results with each other. Finally, future research needs to be conducted in other fields and contexts to test for uniformity and accuracy due to possible common method biases.

7- Declarations

7-1- Author Contributions

Conceptualization, T.V.P. and T.D.T.; methodology, T.V.P. and T.D.T.; software, T.V.P.; validation, T.V.P. and T.D.T.; formal analysis, T.D.T.; investigation, T.D.T.; resources, T.V.P.; data curation, T.V.P. and T.D.T.; writing—T.V.P.; writing—review and editing, T.V.P. and T.D.T.; visualization, T.V.P.; supervision, T.V.P. and T.D.T.; project administration, T.V.P. and T.D.T.; funding acquisition, T.V.P. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

7-4- Institutional Review Board Statement

Not applicable.

7-5- Informed Consent Statement

Informed consent was obtained from all individual participants included in the study.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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