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Embracing imperfections: a predictive analysis of factors alleviating adult learners' digital learning stress on Singapore's lifelong learning journey

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ABSTRACT

This research paper examines the intersection of self-determination theory and its constructs of autonomy, competence and relatedness with the effects of learning support levers available to online educators. The learning support levers of social, technical and financial support are considered against their ability to impact online learning satisfaction and overall digital well-being. In surveying 246 adult learners, the research analysis uses structural equation modelling to yield results that highlight the opportunity for suitably planned social and technical support design to enhance the effectiveness of online teaching and learning. The overall findings add to understanding in the domain of digital learning effectiveness and possible strategies for improving online teaching and learning instructional design, including the surrounding environmental support variables. The paper further highlights the benefits of a cross domain approach to exploring learning effectiveness goals in a digital context. Given the increased prevalence of online education, the methodology and resultant findings of this paper are novel, reflecting the lack of research in the digital learning domain.

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Introduction

As part of the national initiative to encourage lifelong learning among Singaporeans, the government has since 2018 implemented a series of programs to support upskilling and reskilling of workers from fresh graduates to mid-careers workers through on-the-job training, mentorship and various education programs (Kim et al., 2021). Also known as the SkillsFuture, it is a national movement that aims to empower Singaporeans to reach their full potential through continuous education and training throughout their life,

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regardless of their starting point (Skills Future, 2024). The movement is led by the tripartite SkillsFuture Council, which coordinates and drives a national effort to help Singaporeans develop skills relevant to the future (C. Tan, 2016).

This commitment to lifelong learning has necessitated a fundamental shift in HRD practices, where organisations are now obligated to provide continuous learning opportunities and foster a culture of development among their employees (C. Tan, 2016). While the two concepts are interconnected, they are bounded differently. Lifelong learning encompasses a broader spectrum of learning initiatives and policies beyond traditional HRD practices. Hence, we argue that lifelong learning should be viewed as an extended concept of HRD, encompassing not only formal training programs but also informal learning opportunities and self-directed learning initiatives. For one, lifelong learning reframes HRD from being primarily a one-time training process to an ongoing, continuous development journey that effectively support employees at all career stages (Hwang & Yoon, 2023). At the same time, it would also mean personalised training route map, with multiple feedback loops to identify areas for improvement and adjust learning plans accordingly (Lock et al., 2021). In other words, HRD practices would become more agile and adaptable to meet the rapidly changing demands of the workforce and industry. It can be quickly adjusted to address emerging skills and knowledge gaps.

The drive for lifelong learning has spurred more adult learners to enrol in courses and take up training, fuelling the demand for such programs including those conducted online. For HRD practitioners, online training and learning (OTL) programs is not merely a supplementary offering to traditional face-to-face instruction (Arora & Suri, 2020). Instead, it is a necessity change. After the pandemic, changes in the global situation led to the emergence of new workplace technologies and demands for new skillsets, shaping what individuals learn and how individuals learn (Bennett & McWhorter, 2021; Delany, 2021). The significant advantages that OTL brings to the table has also prompted HRD practitioners to integrate it as a permanent component of their offerings. First, OTL is regarded as a learner-centric approach, providing greater flexibility and autonomy over learning experience (Anderson, 2020). Second, it incorporates both synchronous and asynchronous tools, including email, discussion boards, chats, and video conferencing, thereby catering to a variety of learning preferences (Scully-Russ & Torraco, 2019). With the rapid pace of workplace automation, OTL allows employees to remain flexible in their learning, rapid acquirement of skills at a cost-effective manner, and thus, providing value that machines could not replicate (Bennett & McWhorter, 2021). Despite these, there are apparent research gaps that provide opportunities for HRD professionals and researchers to further explore the evolving dynamics of OTL and its relevance in the context of lifelong learning and workforce development.

A conspicuous research gap revolves around the effectiveness of support mechanisms for adult learners in OTL environments. While the adoption of OTL has surged, it has raised unforeseen challenges, particularly concerning adult learners. It has been well documented that adult learners faced additional challenges such as managing various responsibilities and financial constraints, resulting in increased levels of stress, anxiety, and depression (K.-L. Tan et al., 2022). For instance, adult learners with significant familial responsibilities may struggle to find dedicated time for studying or participating in online classes (Park & Choi, 2009). Similarly, work commitments may interfere with attending live online sessions or completing assignments on time, while personal relationships may compete for attention and focus, potentially impacting the quality of

learning experiences and outcomes (K.-L. Tan et al., 2022). Seeing from the above, the existing body of literature has acknowledged the presence of these issues, but it lacks comprehensive research that explores the interrelationships between support mechanisms (such as mentorship programs, peer support networks), learners' psychological needs, and their intrinsic motivation in OTL, particularly in the context of adult learners. For instance, Ahmed et al. (2020) have crafted a framework to support employees in managing OTL, but it is incomplete as it did not consider other factors that adult learners faced in the course of learning. Besides, Ahmed et al. (2020) fallen short in furnishing empirical evidence that obscured the framework's true potential, limiting its impact and hindering our understanding of its real-world utility. By not having clarity in this area, HRD practitioners would not be adequately equipped to develop and implement effective support strategies to reduce adult learners digital stress in OTL environments.

Additionally, it is also of great interest to gain insights into adult learners' basic psychological needs. According to Van den Broeck et al. (2016), the basic psychological needs (i.e. needs for autonomy, competence, and relatedness) plays a pivotal role in sustaining the motivation and resilience of adult learners, particularly in the face of challenges encountered in the course of learning and development. Previous studies, such as K.-L. Tan et al. (2022), have highlighted that the fulfilment of these basic psychological needs is essential for adult learners' intrinsic motivation towards seeking novelty, pursuing optimal challenges, and expanding their capabilities to learn and explore. However, it is essential to emphasise that there is a scarcity of studies addressing the influence of these factors within OTL environments (Manoharan et al., 2022). Considering that motivation is an essential aspect of the learning process, gaining insights into adult learners' motivation in OTL can help HRD practitioners to develop an optimal environment for effective learning to occur (Manoharan et al., 2022). This argument aligns with Rigby and Ryan (2018) perspective that for HRD to succeed, there is a need to tap into employees' basic psychological needs where employees would determine the valence of workplace experiences. At the same time, it supports the adult learning theory, highlighting that while adults respond to external motivators to learn, they are mostly driven by internal factors which includes fulfilling their need for competence, autonomy and relatedness (Hwang & Yoon, 2023).

Finally, this study utilises predictive modelling, which distinguishes it from prior research efforts. The goal is to go beyond knowing what has happened to provide the best assessment of what will happen in the future (Shmueli et al., 2019). Without an additional assessment of predictive power, the managerial implications of academic research papers like Agyeiwaah et al. (2022), Manoharan et al. (2022) may be less transitive, as we cannot be sure that the model estimates will yield similar results across time, samples, and context. Assessing a statistical model's predictive power is equally important to identify the likelihood of future outcomes based on historical data, as many organisations use academic research papers to develop frameworks, policies and practices for adult online learners.

In sum, this study will examine if the three key perspectives of support mechanisms: social support, technical support, and financial support enhance adult learners' OTL experience. Specifically, we extend the existing body of knowledge in HRD by further examining how the three support mechanisms influence adult learners' need for autonomy, competency and relatedness, thereby leading to an increase of

satisfaction in OTL, and a reduction in digital learning stress. We believe this study deepens our understanding of the intricate dynamics of adult learning in the digital age. In the process, it will provide a fresh perspective to adult learning theory by supporting it with empirical insights into the support mechanisms and psychological needs of adult learners in OTL environments. The results would advance the field of HRD and promoting the growth and adaptability of their employees in an ever-evolving digital landscape.

Literature review

Context of study

The Singapore government has launched several initiatives to support upskilling and reskilling initiatives, such as the SkillsFuture initiative, which encourages individuals to take ownership of their learning and skills development (K.-L. Tan et al., 2022). At the same time, it has also introduced the SkillsFuture Earn and Learn program, which provides structured on-the-job training and mentorship for fresh graduates and mid-career workers (Kim et al., 2021). Overall, Singapore has been taking a proactive approach towards upskilling and reskilling its workforce, recognising the need for life-long learning and continuous skills development to stay competitive in the global market. O. S. Tan and Kwek (2022) further argue that the focus should now shift towards redesigning pedagogies that foster resilient, confident, and adaptable learners. As a result, this study is well placed to focus on adult learners in Singapore, given the government's emphasis on upskilling and reskilling initiatives to promote lifelong learning and stay competitive in the global market.

Theoretical framework

Self-Determination Theory (SDT) is widely used to explain learners' motivation to enhance their growth trajectory based on their needs for autonomy, competence, and relatedness (Chiu, 2021). SDT provides a framework for understanding and promoting motivation in OTL contexts, as it suggests that supportive teaching significantly relates to learners' intrinsic motivation (Deci & Ryan, 2000). It can be inferred from several studies that designing learning activities that allow students to feel competent in their abilities, providing them with choices and control over their learning experiences (autonomy), and creating opportunities for students to interact and build relationships with their peers and instructors (relatedness) can enhance their motivation and engagement (Chiu, 2021; Huang & Wang, 2023). However, there has been a lack of research that indicates the factors affecting adult learners' basic psychological needs for autonomy, competence, and relatedness. To complement SDT, the Adult Learning Theory provides a valuable lens to understand adult learners' motivations and needs (Hwang & Yoon, 2023). According to Knowles, adult learning is characterised by the assumptions that adult learners are driven both extrinsically and intrinsically to take a proactive role in orchestrating their learning pathways (Park & Choi, 2009). Aligning with these propositions and integrating with SDT, this study (see Figure 1) creates

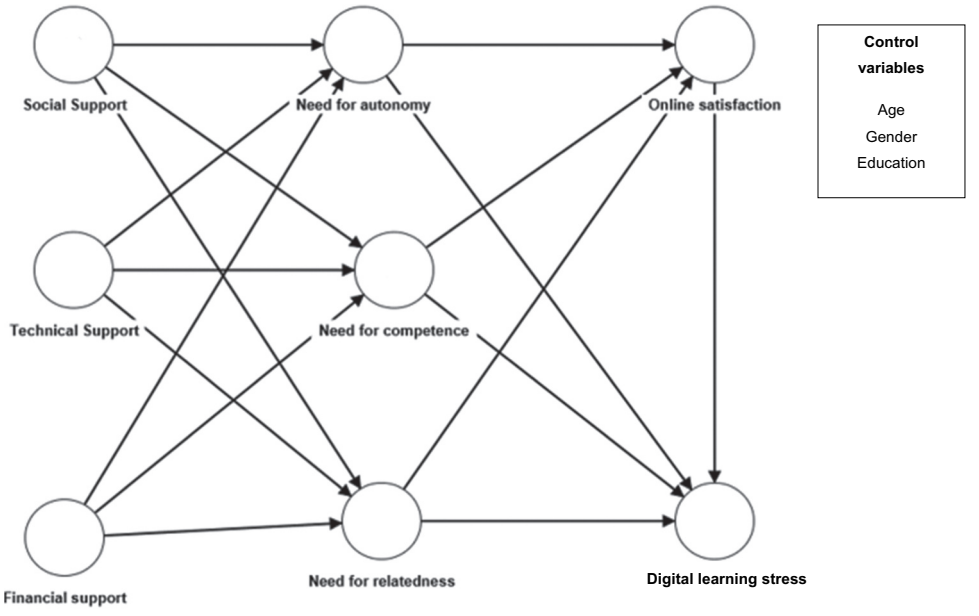

Figure 1. Conceptual model.

a comprehensive framework for understanding how social, technical, and financial factors can influence adult learners' basic psychological needs, thereby enhancing their motivation, engagement, and overall satisfaction in online teaching and learning contexts.

Social support on basic psychological needs

Social support is crucial for adult learners as they often engage in self-directed learning activities, limiting interaction with instructors and co-learners. This support helps meet their psychological needs, providing resources, encouragement, and emotional support, making them feel in control, capable, and connected to others. Studies such as Büchi (2021) found social support can provide resources, information, and feedback that help individuals make informed decisions and feel more in control of their learning activities (autonomy). Similarly, social support fufills needs for competence as it can offer encouragement, feedback, and opportunities for learning and growth, helping adult learners to develop new skills and feel more capable (Chiu, 2021). Finally, Martin and Borup (2022) demonstrated that when students received social support, it increased connectedness, which enhance their sense of relatedness. Based on the above body of research, our first set of hypotheses are:

H1a. Social support positively influences the need for autonomy.

H1b. Social support positively influences the need for competence.

H1c. Social support positively influences the need for relatedness.

Technical support on basic psychological needs

Technical support is a service provided to help users solve technical problems they encounter with their products or services. In the context of OTL, technical support refers to the assistance provided to online learners to help them overcome technical issues they encounter when using OTL platforms, software, or hardware (Zheng et al., 2018). As such, it is not surprising that other studies such as Zheng et al. (2018) identify technical support as an important contributory factor to the learning experience of online learners. It was largely acknowledged across literature such as Pettigrew and Howes (2023) that the provision of technical support as a lever addresses adult learners basic psychological needs as it provides them with the support needed to (1) control their learning environment (autonomy); (2) develop their technical skills (competence); and (3) increase communication and collaboration across time and space (relatedness). However, the role of technical support in meeting the basic psychological needs of online learners is complex and sometimes contradictory (Bazarova et al., 2017). While technical support is essential in OTL, learners may feel a loss of control, autonomy, and competence when relying on support staff to fix issues. Additionally, technical support interactions can exacerbate feelings of isolation and detachment if the support staff disrespect learners' technical abilities. Given these inconclusive findings, it gives us sufficient grounds to believe that the role of technical support on basic psychological needs warrant more investigations, leading us to the following set of hypotheses:

H2a. Technical support positively influences the need for autonomy.

H2b. Technical support positively influences the need for competence.

H2c. Technical support positively influences the need for relatedness.

Financial support on basic psychological needs

Besides, the lack of financial support directly impacts their intent to remain in their online courses (Park & Choi, 2009). Financial difficulties can negatively affect the students' mental health (Park & Choi, 2009). In this respect, financial support was shown to increase online learners' sense of autonomy by providing them with the resources necessary to take control of their learning (Chiu, 2021). Besides, financial support can escalate online learners' need for relatedness by facilitating connections with others who share their interests and goals (McGill et al., 2014). Overall, this preceding body of research offers insight into the attenuating impact of social support, encouragement, and a sense of belonging, which can impact the level of continued motivation and commitment to continue their OTL course. Based on the foregoing scholarly debates, we hypothesise:

H3a. Financial support positively influences the need for autonomy.

H3b. Financial support positively influences the need for competence.

H3c. Financial support positively influences the need for relatedness.

Basic psychological needs regarding online satisfaction and digital learning stress

Adult learners need to have control of their own course goals and behaviours to feel self-determined. According to the SDT, when individuals' behaviours are autonomously motivated, they experience eudaimonic well-being when they achieve their perceived potential and have the opportunity for personal growth as indicated by a satisfaction of their basic needs (Deci et al., 2017). For instance, Agyeiwaah et al. (2022) found online students faced a high sense of ownership when learners felt autonomous over their learning process, leading to greater engagement, motivation, and satisfaction with their OTL experience. Comparable results were found in Matsuo et al. (2022).

Similarly, the need for competence refers to the desire to feel capable and effective in one's actions and accomplishments (Deci & Ryan, 2008). In the context of OTL, this might involve the desire to master new skills or knowledge, complete tasks or assignments successfully, or receive positive feedback and recognition for one's efforts (Chiu, 2021). When learners feel competent, they are more likely to experience a sense of achievement, satisfaction, and motivation. In this regard, Barber (2021) found that learners' perceived competence was positively related to their satisfaction with OTL. Concomitantly, fulfilling the need for competence reduces OTL anxiety, feeling more confident in their abilities and less overwhelmed by the challenges faced in their studies (Agyeiwaah et al., 2022).

Finally, the need for relatedness is important for supporting online satisfaction and digital well-being for online learners. Relatedness contributes to online learners' emotional well-being. When learners feel connected to others, they are less likely to feel isolated or lonely, which contributes towards any learning anxiety (Huang & Wang, 2023). Positive relationships can provide learners with emotional support and contribute to their overall sense of well-being. Furthermore, the need for relatedness can facilitate collaboration among learners, which can enhance their learning experience and support their digital well-being (Kusurkar et al., 2020). Based on the above arguments, our next set of hypotheses are:

H4a. Need for autonomy negatively influences digital learning stress.

H4b. Need for autonomy positively influences online satisfaction.

H5a. Need for competence negatively influences digital learning stress.

H5b. Need for competence positively influences online satisfaction.

H6a. Need for relatedness negatively influences digital learning stress.

H6b. Need for relatedness positively influences online satisfaction.

Online satisfaction on digital learning stress

Digital learning stress may include poor interactivity among online learners, unclear workloads and evaluation systems that require quick solutions but are often not provided with technical support (Chang et al., 2021). In this regard, when one is satisfied with OTL, they are more likely to engage with technology in a way that supports their overall well-being, leading to a reduction in digital learning stress. This highlights the importance of ensuring that online learners have a positive experience and are satisfied with their online learning environment to reduce the potential negative impact of digital learning stress on their overall well-being and motivation. Based on this, our final hypothesis is:

H7. Online satisfaction negatively influences digital learning stress.

Methodology

Sample and procedure

Using convenience sampling, the data were gathered in June 2022 through an online self-administered survey from adult learners in Singapore. We adopted 18 years old as the cut-off age as the minimum legal age to work in Singapore is 17 years and above (Ottavia, 2022). Similar criteria has been used for studies such as K.-L. Tan et al. (2022). To ensure that only bona-fide respondents participate in the survey, a filter question was set, asking if respondents have experienced OTL in the past one year. The sample size was determined using the power analytic method (Cohen, 1988). With 80% power, an effect size of 0.05 and with four predictors would require a minimum sample size of 85. Concomitantly, this study leveraged the inverse square root method, developed by Kock and Hadaya (2018), where they have indicated that the minimum recommended sample size for any PLS-SEM application is estimated to be 160. To this end, this study's overall response rate of 246 exceeds both requirements.

Controlling method bias

As this is a cross-sectional survey, it is important to address potential common method bias. First, the survey instrument was pretested where a team of five researchers reviewed the survey form to ensure that it was clear, specific, and concise, and that there were no ambiguous or vague concepts (Memon et al., 2017). Second, it was emphasised that all responses collected would be anonymous, confidential, and voluntary. Third, a temporal separation was created by placing demographic questions between the predictors and the criterion. This was done to prevent any apparent connection or relationship between the predictor variables and the criterion variables, as suggested by Podsakoff et al. (2003). Additionally, we deployed the Harman single-factor test, and the results indicated that no single component explained more than 50% of the covariance between the items and criterion constructs, suggesting that common method bias is not a major concern in this study (Rodríguez-Ardura & Meseguer-Artola, 2020).

Control variables

To further minimise possible confoundment of results, we controlled age, gender and education in this model. Following Sun et al. (2022), age has been suggested as a significant factor in determining one's propensity of experiencing digital learning stress. After all, it has been well documented across literatures such as Morris and Venkatesh (2000) that younger generation of adult learners display higher adaptability and digital literacy that allows them to be more comfortable with technology. Additionally, gender role expectations would shape one's ability in computer and internet usage. For instance, many societies exist stereotype that men are expected to be more technologically competent, resulting in significant digital stress when they see themselves not meeting these expectations (Galyani Moghaddam, 2010). Finally, higher levels of education are found to predict the use of technology (Czaja et al., 2006). Besides, being higher educated can provide access to resources and support networks that help individuals manage digital stress. Hence, well-educated individuals may have a better understanding of where to seek assistance when facing technological challenges (Czaja et al., 2006). Therefore, controlling age, gender and education allowed the researchers to identify if the variables extraneously affected the phenomena that were being investigated. In this regard, the results in Table 4 show that none of these control variables display any form of significant relationship with the endogenous variable.

Measures

Social support

The seven items of social support are adapted from Zimet et al. (1988). These items are measured on a 7-point Likert scale. The Cronbach's alpha and composite reliability scores are 0.875 and 0.903, respectively. Sample items include, 'I get the emotional help & support I need from my family when I encounter difficulties during online training'. and 'I can talk about the problems I met during online training with my friends'.

Technical support

The seven items of technical support are adapted from Wei et al. (2011). These items are measured on a 7-point Likert scale. The Cronbach's alpha and composite reliability scores are 0.856 and 0.913, respectively. Sample items include, 'A specific person or group of people are available for assistance with any queries about online training'. and 'I receive sufficient support from my school/training institution while I use the digital platforms for online training'.

Financial support

The three items of financial support are adapted from Claridge and Ussher (2019). These items are measured on a 7-point Likert scale. The Cronbach's alpha and composite reliability scores are 0.762 and 0.863, respectively. Sample items include, 'I feel positive that the school/training institution recognized that I may need some financial help for

online training'. and 'I am aware of financial support that influences me to pursue online training'.

Basic psychological needs

The 14 items relating to the SDT are adapted from (Deci et al., 2017). The Cronbach's alpha score is 0.889 (need for autonomy), 0.913 (need for competence) and 0.926 (need for relatedness), while the composite reliability score is 0.918 (need for autonomy), 0.939 (need for competence) and 0.945 (need for relatedness). The items are measured on a 5-point Likert scale. Sample items for the need for autonomy, need for competence and need for relatedness are 'I have a choice in what I want to learn'., 'I feel competent after participating in online learning'. and 'With the other students in online learning, I feel supported'., respectively.

Online course satisfaction

The four items of online course satisfaction are adapted from Agyeiwaah et al. (2022). These items are measured on a 5-point Likert scale. The Cronbach's alpha and composite reliability scores are 0.945 and 0.961, respectively. Sample items are 'I truly enjoy the experience of studying via the online learning platform'. and '1 feel good about the decision to study via the online learning platform'.

Digital learning stress

The four items on online course satisfaction are adapted from S. Huang et al. (2022). These items are measured on a 5-point Likert scale. The Cronbach's alpha and composite reliability scores are 0.921 and 0.944, respectively. Sample items include, 'I was anxious because I am unable to communicate clearly during online learning'. and 'I felt anxious because I cannot find the information I want during online learning'.

Method of analysis

We utilised PLS-SEM to analyse the data that we collected. PLS-SEM stands out as a suitable option for such scenarios, primarily due to its ability to handle small sample sizes effectively, a feature lacking in traditional covariance-based SEM (Hair, Matthews, et al., 2017). Additionally, its flexibility in accommodating complex models with numerous variables and intricate relationships makes PLS-SEM an ideal choice (Hair, Hult, et al., 2017). Additionally, PLS-SEM has been utilised in various contexts, such as tourism (Tan, Hii, et al., 2023), events (Tan, Ho, et al., 2023), education (Sim et al., 2020), human resources (Ringle et al., 2020), and consumer behaviour (Le et al., 2021). The concept of predictive analysis models holds significance both in practical application and theoretical understanding (Shmueli et al., 2019). Practically, predictive analysis models serve to inform decision-making processes, anticipate trends, and identify potential risks or opportunities across various domains (Shmueli et al., 2019). In the context of PLS-SEM, predictive analysis can be seamlessly integrated to forecast outcomes or behaviours

Table 1. Respondents profile.

Demographics ($n = 246$)	Number	Percentage
Gender		
Male	124	50.41%
Female	114	46.34%
Prefer not to say	8	3.25%
Age group		
18–24 years old	99	40.24%
25–34 years old	60	24.39%
35–44 years old	31	12.60%
45–54 years old	29	11.79%
55 years old and above	27	10.98%
Education		
Doctorate	12	4.88%
Master degree	42	17.07%
Bachelor degree	118	47.97%
Diploma	61	24.80%
Certificate	13	5.28%

based on identified structural relationships. By leveraging PLS-SEM for understanding underlying relationships and predictive analysis for forecasting future trends, we can enhance the relevance and applicability of their findings, bridging the gap between theory and practice in empirical research. Following the recommendations by Hair, Hult, et al. (2017), we adopted a two-stage approach of assessing the measurement model followed by the structural model.

Results

Respondents' profile

Table 1 provides a breakdown of the respondents' profile. Among the 246 respondents, there is an almost equal distribution of gender with male representing 50.41% and rest being female respondents (46.34%). Additionally, 40.24% of them are aged from 18 to 24 years old with the least number of respondents being 55 years old and above (10.98%). In terms of education, majority has a bachelor's degree (47.97%) followed by diploma (24.80%).

Measurement model

The results in Table 2 indicate that the construct reliability and convergent validity requirements were met. Firstly, most of the loadings on the items exceeded the threshold value of 0.708 as recommended by Hair, Hult, et al. (2017). For the item loading for SS1 which falls below this threshold, it is retained as the associated latent variable to the items fulfilled the criteria of at least 0.50 for the average variance extracted (AVE), 0.70 for Cronbach's alpha, and 0.70 for composite reliability (Hair, Hult, et al., 2017). Table 3 confirms that discriminant validity was achieved, with heterotrait–monotrait (HTMT) criterion values being lower than 0.90 (Henseler et al., 2015). Overall, the results demonstrate that the proposed model exhibited good reliability, convergent validity, and discriminant validity.

Table 2. Measurement model.

	Outer loading	CA	CR	AVE
AUT1	0.812	0.889	0.918	0.693
AUT2	0.829			
AUT3	0.842			
AUT4	0.812			
AUT5	0.865			
COMP1	0.848	0.913	0.939	0.794
COMP2	0.902			
COMP3	0.904			
COMP4	0.908			
DS1	0.903	0.921	0.944	0.808
DS2	0.901			
DS3	0.91			
DS4	0.881			
FS1	0.79	0.762	0.863	0.678
FS2	0.875			
FS3	0.802			
OS1	0.904	0.945	0.961	0.859
OS2	0.937			
OS3	0.925			
OS4	0.942			
REL1	0.882	0.926	0.945	0.775
REL2	0.898			
REL3	0.915			
REL4	0.936			
REL5	0.762			
SS1	0.696	0.875	0.903	0.572
SS2	0.79			
SS3	0.764			
SS4	0.801			
SS5	0.744			
SS6	0.711			
SS7	0.781			
TS1	0.898	0.856	0.913	0.777
TS2	0.909			
TS3	0.836			

Note. AUT: needs for autonomy, COMP: needs for competence, DS: digital learning stress, FS: financial support, OS: online learning satisfaction, REL: needs for relatedness, SS: social support, TS: technology support.

Table 3. Discriminant validity.

	Constructs	1	2	3	4	5	6	7	8
1	Digital learning stress								
2	Financial support	0.162							
3	Need for autonomy	0.128	0.506						
4	Need for competence	0.245	0.475	0.751					
5	Need for relatedness	0.075	0.554	0.714	0.682				
6	Online satisfaction	0.238	0.455	0.724	0.858	0.68			
7	Social Support	0.099	0.575	0.618	0.651	0.718	0.563		
8	Technical Support	0.150	0.561	0.674	0.664	0.577	0.669	0.635	

Note. HTMT achieved at $HTMT_{0.90}$.

Structural model

Following the establishment of the model's validity and reliability, the next stage would be assessing the structural model. Prior to that, possibilities of multicollinearity should be examined. In this regard, Table 4 shows that the variance inflation factors (VIF) are less

Table 4. Structural model.

	Path	Path coefficient	Standard error	t-value	VIF	5.00%	95.00%	f^2	R^2
H1a	Social Support -> Need for autonomy	0.283	0.091	3.128**	1.571	0.13	0.427	0.089	0.429
H1b	Social Support -> Need for competence	0.350	0.073	4.795***	1.571	0.22	0.462	0.141	0.448
H1c	Social Support -> Need for relatedness	0.472	0.067	7.002***	1.571	0.358	0.578	0.272	0.478
H2a	Technical Support -> Need for autonomy	0.384	0.076	5.068***	1.543	0.262	0.508	0.168	
H2b	Technical Support -> Need for competence	0.364	0.077	4.746***	1.543	0.241	0.494	0.155	
H2c	Technical Support -> Need for relatedness	0.181	0.076	2.379**	1.543	0.049	0.302	0.041	
H3a	Financial support -> Need for autonomy	0.112	0.065	1.717*	1.376	0.004	0.217	0.016	
H3b	Financial support -> Need for competence	0.073	0.061	1.194$^{(NS)}$	1.376	−0.031	0.171	0.007	
H3c	Financial support -> Need for relatedness	0.167	0.059	2.849**	1.376	0.068	0.259	0.039	
H4a	Need for autonomy -> Digital learning stress	0.046	0.103	0.442$^{(NS)}$	2.263	−0.13	0.207	0.001	0.075
H4b	Need for autonomy -> Online satisfaction	0.170	0.069	2.455**	2.173	0.059	0.286	0.042	0.679
H5a	Need for competence -> Digital learning stress	−0.208	0.098	2.115*	3.148	−0.351	−0.022	0.015	
H5b	Need for competence -> Online satisfaction	0.582	0.080	7.304***	2.092	0.449	0.713	0.505	
H6a	Need for relatedness -> Digital learning stress	0.168	0.095	1.766*	2.026	0.002	0.317	0.015	
H6b	Need for relatedness -> Online satisfaction	0.159	0.083	1.917*	1.948	0.033	0.307	0.04	
H7	Online satisfaction -> Digital learning stress	−0.192	0.110	1.738*	3.115	−0.365	−0.001	0.013	
	Control variables								
	Age -> Online satisfaction	0.022	0.039	0.567$^{(NS)}$					
	Edu -> Online satisfaction	0.021	0.037	0.575$^{(NS)}$					
	Gender -> Online satisfaction	0.044	0.044	0.984$^{(NS)}$					

Note. NS: not significant; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

than 3.3, indicating that multicollinearity is not a serious concern in our model (Hair, Hult, et al., 2017).

Table 4 also shows that social support is instrumental in fulfilling respondents' needs for autonomy (H1a. $\beta = 0.283$, $p < 0.01$), needs for competence (H1b. $\beta = 0.350$, $p < 0.001$) and needs for relatedness (H1c. $\beta = 0.472$, $p < 0.001$). Similarly, technical support has been found to meet the three basic psychological needs for autonomy (H2a. $\beta = 0.384$, $p < 0.001$), needs for competence (H2b. $\beta = 0.364$, $p < 0.001$) and needs for relatedness (H2c. $\beta = 0.181$, $p < 0.01$). Financial support, on the other hand, only positively influence needs for autonomy (H3a. $\beta = 0.112$, $p < 0.05$), and needs for relatedness (H3c. $\beta = 0.167$, $p < 0.01$), but not needs for competence (H3b. $\beta = 0.073$, $p = 0.116$). Summarizing these results, H3b is not supported, while H1a, H1b, H1c, H2a, H2b, H2c, H3a and H3c are all supported.

The next set of results focus on the role of the three basic psychological needs towards improving online satisfaction and reducing digital learning stress. Table 4 presents the findings that fulfilling the need for autonomy has a positive and

Table 5. Predictive analytics.

	Q^2 predict	PLS-SEM_RMSE	LM_RMSE	PLS-LM
DS1	0.013	1.160	1.191	−0.031
DS2	0.003	1.097	1.142	−0.045
DS3	0.005	1.126	1.154	−0.028
DS4	0.014	1.179	1.210	−0.031
AUT1	0.302	0.835	0.849	−0.014
AUT2	0.269	0.818	0.870	−0.052
AUT3	0.225	0.809	0.841	−0.032
AUT4	0.277	0.725	0.775	−0.050
AUT5	0.295	0.762	0.791	−0.029
COMP1	0.341	0.712	0.739	−0.027
COMP2	0.336	0.701	0.735	−0.034
COMP3	0.328	0.737	0.763	−0.026
COMP4	0.335	0.809	0.822	−0.013
REL1	0.397	0.709	0.740	−0.031
REL2	0.381	0.725	0.782	−0.057
REL3	0.330	0.772	0.808	−0.036
REL4	0.428	0.698	0.726	−0.028
REL5	0.220	0.772	0.839	−0.067
OS1	0.306	0.718	0.747	−0.029
OS2	0.345	0.711	0.722	−0.011
OS3	0.325	0.767	0.787	−0.020
OS4	0.349	0.693	0.714	−0.021

Note. AUT: needs for autonomy, COMP: needs for competence, DS: digital learning stress, OS: online learning satisfaction, REL: needs for relatedness.

significant relationship with online satisfaction (H4b. $\beta = 0.170$, $p < 0.05$), but not with digital learning stress (H4a. $\beta = 0.046$, $p = 0.329$). Conversely, fulfilling the need for competence has a negative and significant relationship with digital learning stress (H5a. $\beta = -0.208$, $p < 0.05$), and a positive and significant relationship with online satisfaction (H5b. $\beta = 0.582$, $p < 0.001$). The results also show that fulfilling the need for relatedness has a positive and significant relationship with both digital learning stress (H6a. $\beta = 0.168$, $p < 0.05$) and online satisfaction (H6b. $\beta = 0.159$, $p < 0.05$). Finally, online satisfaction has a negative and significant relationship with digital learning stress (H7. $\beta = -0.192$, $p < 0.05$). Given that H4a did not produce results that align with the hypotheses, only H4b, H5a, H5b, H6a, H6b and H7 are supported.

Table 4 shows that the R^2 value of online satisfaction is 0.679, indicating that the determinants account for 67.9% variance in online satisfaction, which, according to Cohen (1992), is considered a substantial model. Similarly, substantial models are observed in the three forms of support, which accounted for 42.9%, 44.8% and 47.8% of the variance in needs for autonomy, needs for competence and needs for relatedness, respectively. On this note, the R^2 value of 0.075 for digital learning stress represents a small model. On effect sizes (f^2), Table 4 shows that most effect sizes are considered small to medium, ranging from 0.013 to 0.272 (Cohen, 1988). The effect sizes of financial support on need for competence and need for autonomy on digital learning stress are negligible, which aligns with its non-significant results. Finally, the need for competence displayed substantial effects in producing the outcomes of online satisfaction ($f^2 = 0.505$).

Predictive analytics

Predictive analytics is a crucial component of quantitative research that enables organisations to utilise historical data to estimate the probability of similar behaviour. We utilised the PLS predict technique to perform predictive analysis. According to Table 5, the results demonstrated that all of the values of the root mean squared error (RMSE) values for the PLS model were smaller than that of the linear model (LM), indicating that the model has strong predictive power.

Discussions

Grounded on the SDT, this study examined the predictors that fulfil the three basic psychological needs of adult learners and how the fulfiling these needs reduces digital learning stress. The findings indicate that the presence of social and technical support fulfil the three basic psychological needs for autonomy, need for competence and need for relatedness. These results align with existing studies such as Tan et al. (2022). One possible reason for this result is the intricate nature of OTL environments. Although OTL offers convenience, Agyeiwaah et al. (2022) highlighted that adult learners encounter additional challenges, such as work responsibilities and family commitments, which add a layer of complexity to their learning experiences. In aligning with these results, it is imperative that different forms of social and technical support, such as employer flexibility, technical helplines and peer support systems, are made available. Due to the absence of interpersonal interactions that are traditionally available to on-campus learners, the provision of social and technical support play an even more crucial role in engaging, motivating, and retaining adult online learners.

These reasons further explain why our results demonstrated that financial support fulfils the need for autonomy and relatedness. For any form of scholarly pursuits, a key consideration is specific financial consideration available for them to complete the study (Claridge & Ussher, 2019). Financial support would provide adult learners with more choices when it comes to customising their trajectory of learning. In other words, they have the resources to explore their interests and passions and take courses that align with their career objectives. In the same vein, financial support would help them to be part of a community where they perceive their needs are taken care, and such experience would provide a sense of camaraderie where they can further build connections and relationships with their peers, sponsors and faculties (Mbous et al., 2022).

Expectedly, our results demonstrate that fulfilling the three basic psychological needs establishes a positive relationship with satisfaction in OTL. These results aligns with several studies including Autin et al. (2022) and Chiu (2021). When adult learners experience autonomy, competence and relatedness, they perceive themselves to be more empowered towards charting their learning paths, setting own learning goals and determining their pace of learning, which according to Chiu (2021), encourages engagement and satisfaction. It is also not surprising to see that being satisfied with OTL would reduce the propensity of experiencing digital learning distress.

Extending the above arguments, we found that only by satisfying the need for competence reduces one's propensity of experiencing digital learning stress. When one feels competent, they would be more confident of navigating the learning environment,

coping better with the different digital learning stressors, and eventually reducing them feeling overwhelmed. On the other hand, our results show that while autonomy can contribute to satisfaction in OTL, it may not directly reduce digital learning stress, contradicting results from existing studies such as Chiu (2021). A probable reason could be that even if adult learners have control over their learning environment, they may still experience stress if they are unable to navigate technical difficulties or manage their workload effectively. Interestingly, our results demonstrate that relatedness increase OTL distress. While this runs contrary to existing literature (see Chiu, 2021; K.-L. Tan et al., 2022), it is possible that excessive relatedness can lead to stress, particularly if adult learners feel overwhelmed by the social demands of OTL. This is especially so when adult learners, in addition to their day-to-day commitments, felt compelled to attend online discussions, facing peer pressures and risk being isolated from their peers.

Implications

Theoretical implications

This study offers several theoretical contributions with direct implications for the field of HRD. It has accomplished this by investigating and highlighting the intricate interplay between three types of support, the fundamental psychological needs of individuals, satisfaction with OTL, and the stress associated with it, all within a single model. Prior to this study, there was a lack of research that systematically explored how these various elements interacted with one another. Therefore, this research extended Ahmed et al. (2020) model by offering valuable insights into the complex dynamics of OTL environments, shedding light on how support mechanisms, psychological needs, satisfaction, and stress are interconnected and impact the overall online learning experience for adult learners. In doing so, this study responds to the call made by Nachmias and Hubschmid-Vierheilig (2021, p. 129) that understanding the role of support mechanisms in OTL is the only way 'we can have a meaningful participation as HRD professionals in the creation of future learning practices in organizations'.

Secondly, it provides a fresh outlook on how SDT integrates with adult learning theory, especially in the digital learning environment. While numerous studies have explored the influence of SDT on optimising learning, it largely constrained to in-person delivery and pre-employment training (Chiu, 2021). Yet, it is noteworthy that Deci et al. (2017) emphasised that the SDT can also be applied across other domains including work motivation and management. In this context, Mueller and Lovell (2015) has indicated that HRD's contribution to literature can be improved by furthering knowledge on employees' inner psychological experiences. By incorporating these perspectives in our research design, this study has made a substantial contribution to HRD's literature by being one of the first few studies integrating the different levers mechanisms and individual's psychological perspectives, thereby enriching both SDT and adult learning theory.

Finally, the robustness of the research model is underscored by the inclusion of predictive analysis. This component of the study goes beyond simply explaining observed phenomena and extends into forecasting future outcomes – an aspect that has been highlighted as particularly crucial by Sarstedt and Danks (2021) for researchers within

the social sciences discipline. Doing so enhances the global understanding of online learning environments, contributing to the adaptability and preparedness of HRD professionals worldwide. In sum, incorporating predictive analytics not only enhances our understanding of the content but also equips us with the ability to anticipate and prepare for potential future scenarios, thereby adding a valuable dimension to the research's overall contribution.

Managerial implications

This study's implications for HRD practitioners are particularly pertinent in today's diverse organisational landscapes, characterised by varying cultural backgrounds, ethnicities, and age groups. Our findings underscore the importance of organisations providing requisite care and support tailored to facilitate autonomy in learning and address adult learners' relational needs.

First and foremost, it is imperative to recognise that OTL transcends mere knowledge delivery compared to traditional face-to-face instructional designs. HRD practitioners must exhibit sensitivity to adult learners' distinct learning needs and employ appropriate strategies to provide necessary support. In this regard, human resource personnel could conduct an employee learning needs support assessment exercise individually to identify the intensity of the specific learning supports needed by employees. Following the insights of Greenhow et al. (2022), HRD efforts should commence well before the actual training sessions, encompassing activities such as meticulous planning and design of course materials and content. Establishing a climate of care and concern fosters individuals' sense of learning efficacy, accomplishment, and a favourable perception of the organisation. In other words, the ability to provide various forms of support, such as family support, employer flexibility, and peer networks, can potentially be effective strategies in supporting adult learners in meeting their basic psychological needs. Likewise, technical support such as a helpdesk to address system connectivity and issues would encourage adult learners to have more confidence in managing the OTL system.

Among the three basic psychological needs, fulfilling the need for competence emerges as paramount. HRD should concentrate on bolstering adult learners' sense of self-efficacy by offering targeted support mechanisms. Beyond imparting knowledge, HRD practitioners should guide learners in navigating the technological aspects of OTL environments, aiding in the utilisation of relevant programs and devices. Additionally, mentorship program and regular feedback mechanisms should be instituted to provide learners with insights into their progress, reinforcing areas of proficiency and identifying areas for improvement. Essential to this approach is the provision of clear directives and the establishment of transparent expectations regarding assignments and learning outcomes, aligning with the expectations of adult learners. For adult learners who are experiencing mental well-being issues, HRD practitioners could further provide professional counselling services to these learners to support their psychological needs with the aspiration to minimise adult learners digital stress in OTL environments.

In extending these implications based on our findings, HRD practitioners should also prioritise the provision of culturally sensitive support, acknowledging and accommodating the diverse cultural backgrounds and individual preferences of adult learners. This could involve tailoring learning materials, instructional methods, and support services to

resonate with learners from various cultural contexts. Furthermore, flexibility in learning delivery should be emphasised, recognising that adult learners may have varying time constraints, work commitments, and personal responsibilities. Offering alternative support options for asynchronous learning, flexible scheduling, and personalised learning pathways can enhance learner engagement and satisfaction.

Lastly, collaborative learning opportunities should be fostered within the OTL environment, enabling adult learners to engage in meaningful interactions, peer learning, and knowledge sharing. HRD practitioners can facilitate virtual group discussions, collaborative projects, and online forums to promote social connectedness and collaborative learning experiences. By embracing these recommendations and tailoring HRD initiatives to address the diverse needs of adult learners in OTL environments, organisations can cultivate a culture of continuous learning, empowerment, and professional development, ultimately driving organisational success in today's dynamic global landscape.

Limitations and future directions

This study has the usual limitations of cross-sectional survey. While we have adopted several procedural remedies to prevent common method bias, we could not deny the possibility that respondents could still provide socially desired responses. Hence, future researchers should consider multiple waves of data collection or collecting from different data sources. At the same time, future researchers should consider using random sampling across different countries to ensure a generalisable sample. This study has not attempted to include all relevant predictors affecting OTL satisfaction and reducing OTL stress, which would require extensive effort. To this end, we would encourage future researchers to explore the specific mechanisms necessary to promote the three basic psychological needs in OTL. At the same time, future researchers could conduct multigroup analysis to examine nuance relationship that would be important for organisations to understand in providing more effective support. Likewise, qualitative study is another avenue to unravel new themes that would guide the development of this field of research. Future research might address different types of externally and internally regulated motivation in order to further differentiate our results regarding the relations between basic need satisfaction on OTL satisfaction and OTL distress.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Informed consent

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

Ethics approval

Ethics approval has been obtained from University of Newcastle Australia College Human Ethics Advisory Panel (H-2022–0101).

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