Digital learning space experience and learner continuous use in institutions of higher learning: a moderated-mediation model

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Abstract

Purpose – This paper investigates the moderating-mediation roles of synchronous and asynchronous learning, as well as virtual self-efficacy between digital learning space experience and continuous use among learners in Ghanaian institutions of higher learning.

Design/methodology/approach – A convenience sampling technique was used in the selection of 604 students who answered questions on digital learning space experience, synchronous and asynchronous learning, virtual self-efficacy and learner continuous use within the Greater Accra Region of Ghana. The study employed regression analysis to measure the hypothesized paths.

Findings – The findings show that asynchronous learning partially mediates between digital learning space experience and learner continuous use, but the mediating effect of synchronous learning between digital learning space experience and learner continuous use was not significant. Further, virtual self-efficacy significantly moderates the mediated relationship between asynchronous learning and learner continuous use, but the moderated mediated role of synchronous learning was not established in the study.

Research limitations/implications – Generalization of the study findings is limited due to the sampling scope, which was restricted to students of IHL in the Greater Accra Region of Ghana.

Originality/value – In this research, the academic scope of digital transformation was expanded from both digital structure elements and psychological perspectives within the domain of higher education literature.

Keywords Digital learning space experience, Virtual self-efficacy, Synchronous learning, Asynchronous learning, Continuous use, Ghana

Paper type Research paper

Introduction

Across the globe, there has been an upsurge in academic and practitioner attention on the deployment of digitalization in Institutions of Higher Learning (IHL). Accordingly, IHL have been revolutionized by the advent of artificial intelligence as core services offered within this sector have become ICT (Information Communication Technology) based (Hannan and Liu, 2023). It is noteworthy to add that global pandemics such as COVID-19 have also significantly affected traditional ways of teaching and learning, hence a rapid shift towards the adoption digitalization (Händel *et al.*, 2022). Some scholars argue that digital transformation was birthed by universities (Bygstad *et al.*, 2022; Crawford *et al.*, 2020). These scholars opined that as early as the 1980s through the 2000s, student management portals, learning, library and examination management systems, as well as course websites were deployed by some universities for their primary functions of teaching and learning. This may partly explain the high level of learner readiness towards online learning during the COVID-19 pandemic as revealed by empirical studies (Baxter and Hainey, 2023).

Notwithstanding the relevance of digital learning spaces, factors such as delivery approach, variations in group motivation and design of teaching pedagogy in real-time and offline classes pose several challenges and uncertainties particularly for developing countries (Abdelfattah *et al.*, 2023). Further, the current study argues that empirical evidences on digital learning have predominantly been centred on technology readiness and acceptance with cognitive tools like UTAUT (Unified Theory of Acceptance and Use of Technology) models extensively deployed to explain the phenomenon (e.g. Reyes-Mercado *et al.*, 2023; Tewari *et al.*, 2023). Consequently, issues such as performance expectancy and facilitating conditions have largely been discussed within context to the neglect of learners' psychological perspectives. Thus, the study argues that though digital learning spaces deliver a number of benefits, learners' continuous use is premised on digital competences built through experience (Heidari *et al.*, 2021). The current study addresses gaps in higher education literature by simultaneously examining indirect relationships of synchronous and asynchronous learning, and how virtual self-efficacy strengthens learner continuous use of digital learning spaces within context. Also, the study draws cognitive grounding from both self-determination, as well as, spacing and interleaving theories.

The contributions of the study to higher education literature is highlighted as follows; first, the study extends literature on digitalization in higher education by exploring the phenomenon from the perspective of factors that account for continuous use of digital learning spaces. Second, the paper offers a multi-disciplinary insight as it explores the phenomenon from a number of fields, notably information technology, education and psychology.

Literature review

### Theories grounding the study and hypotheses development

Digital learning space experience and learner continuous use. Within the domain of IHL, digital transformation has been widely discussed in recent years. More specifically, digital transformation has been explored from the perspectives of managerial strategic decision-making, heuristic collaborations and the deployment of telecommunication tools (Bygstad *et al.*, 2022). However, Ellis and Goodyear (2016) assert that it is important for educational

managers and researchers to rethink digital transformation from the viewpoint of virtually enhanced learning processes, which they termed digital learning space. Digital learning space is a multifaceted construct of extreme relevance in contemporary higher education settings, but the subject matter has received little scholarly attention among researchers and practitioners (Bygstad *et al.*, 2022). The authors argue that the relevance of digital learning space stems from its capacity to redefine student–teacher engagements by providing an enabling technologically enhanced environment for deeper learning. In addition, the scholars assert that digital learning spaces equip IHL to perform their primary functions without physical boundaries.

It is a general notion among academics that digital learning space deployment has the capability to replace traditional educational systems because it expands the frontiers of teaching and learning, as it is unrestricted by geographical borders, time or space (Alami and El Idrissi, 2022). Nevertheless, the continuous use of digital tools in IHL is satisfaction driven and premised on the development of right attitudes by instructors and learners towards digital learning spaces (Dubey and Sahu, 2023). Some empirical studies have established a positive association between student experience and continuous use of digital learning modules (Duggal, 2022; Maslov *et al.*, 2021) (see Figure 1). Therefore, the study hypothesized that:

H1. Digital learning space experience has a positive effect on learner continuous use.

Mediating effect of synchronous learning (SYNL). Although, synchronous learning has received quite substantial research attention in educational psychology literature (Fernandez *et al.*, 2022; Moorhouse *et al.*, 2022), its role as a mediator between digital learning spaces and learners' continuous use of technology has not been sufficiently explored. The relevance of synchronous learning stems from its role as an interactive platform that links educators and learners in real-time through mechanisms such as teleconferencing, zoom, live streaming, live chatting and video conferencing (Fernandez *et al.*, 2022). These real-time interactive platforms in some cases are augmented by webcam capabilities that have the propensity to expedite learner engagement, as well as promote learner participation and motivation (Grammens
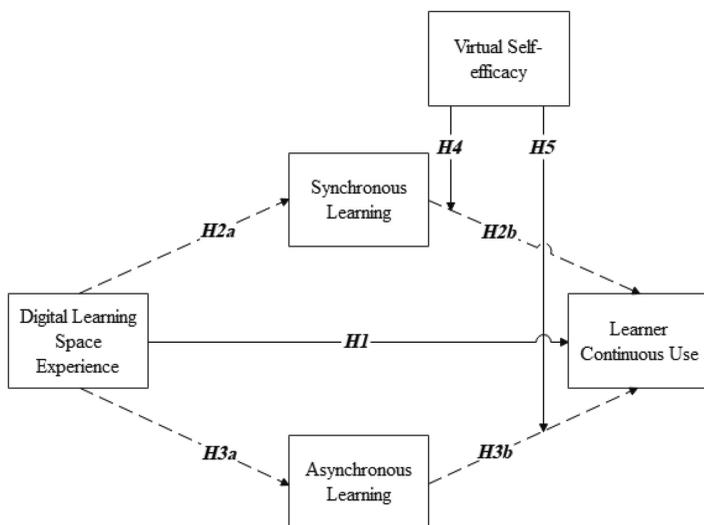
Source(s): Authors' framework (2023)

et al., 2022). These features create a close resemblance of synchronous learning module to traditional classroom delivery approach (Racheva, 2018). Further, synchronous learning presents learners and instructors with access and use of diverse digital affordances to augment educational activities that are otherwise unavailable in offline classroom settings (Jeon *et al.*, 2022). The study draws on the cognitive assumptions of self-determination theory (Ryan and Deci, 2000), which posits that a learner's intrinsic motivation to acquire knowledge is premised on psychological needs of autonomy, relatedness and competence. Further, the theory posits that self-determined behaviors lead to effective and lasting behavioral changes, better performance and adaptive attitudes (Ganotice *et al.*, 2023). Within context, the study asserts that the more learners feel actively engaged, the more satisfied and motivated they are to learn and increase performance in online learning environments (Martin and Bolliger, 2018). Thus, a learner with positive experience of synchronous learning can strive to develop and consolidate motivational inputs needed for continuous use of online learning platforms.

Earlier studies acknowledge significant effect of digital learning space experience on learner continuous use. In a study conducted by Infante-Moro *et al.* (2021), it was revealed that e-learning success explains continuous use of videoconferencing as complement to physical classroom sessions. In another related study, it was unearthed that appropriate use of webcam can stimulate learners' sense of presence and thus reinforces learners' participation in language class (Kozar, 2016). This suggests that features of synchronous learning may indirectly and positively link digital learning space experience with learner continuous use (see Figure 1). Based on these arguments advanced, the study hypothesized that:

H2. Synchronous learning mediates between digital learning space experience and continuous use.

Mediating role of asynchronous online learning (ASYL). The bulk of studies on digital space learning and learner continuous use have not significantly incorporated the mediating effect of asynchronous learning (Huang and Chueh, 2022; Misra *et al.*, 2023). This study argues that different forms of learning modules such as asynchronous learning may help better explain antecedents of continuous use of digital learning spaces. Asynchronous learning describes a situation where flexibility to acquire knowledge is dependent on students' own schedule and convenience. The learning module uses variety of standardized methods that help harness benefits such as pre-recorded audio, digital online library, social media tools and digital forums. The module is predominantly centered on self-guidance and self-regulation, and implemented through self-administration of content at a minimal cost (Fernandez *et al.*, 2022). The current study deploys spacing and interleaving theory (SIT) as a cognitive tool to explain digital learning spaces and continuous use through asynchronous learning.

SIT posit that the deployment of spaced learning chapters with clearly defined breaks and the application of augmented learning experiences positioned in-between learning chapters are key to effective digital learning (Ritter *et al.*, 2007). The study argues that though digital learning space experiences positively influence learners' continuous use of digital tools, this relationship is affected by the role of organized learning episodes as emphasized by the SIT. Thus, the study argues that asynchronous learning acts as a decisive mediator between DLSE and learner continuous use (see Figure 1). On the bases of the assertions made, the study hypothesized that:

H3. Asynchronous learning mediates between digital learning space experience and continuous use.

Moderating role of virtual self-efficacy. To promote digital transformation in IHL, an enabling environment that enhances self-driven desire to learn must be created. Within the field of education, self-efficacy describes a learner's capacity to perform a given task through experiential learning (Peltier *et al.*, 2022). In response to global emergencies like COVID-19, a more reflective

definition was postulated by Park and Avery (2019). The scholars stated that self-efficacy is "an individual's beliefs about whether he/she can successfully complete a given task during a crisis situation" (p. 247). Also, learners' with greater levels of self-efficacy have mastery over their environment (Bandura, 1997). Consequently, amidst the COVID-19 pandemic, learners with higher levels of virtual self-efficacy have a greater chance of easy adoption and continuous use of digital learning spaces. Thus, the current paper argues that the self-determination theory (SDT) provides a good cognitive ground to explain the role of psychological motivators such as virtual self-efficacy in enhancing learners' continuous use of digital learning spaces.

The SDT is grounded in a person's inspiration to pursue a goal for the purposes of gaining basic psychological utility (Ryan and Deci, 2000). The theory primarily thrives on three cardinal pillars, namely; autonomy, competence and relatedness. The study conjectures that through self-determination, learners who build self-efficacy competencies are likely to reap optimum benefits from continuous use of digital learning spaces. Consequently, learners with higher levels of virtual self-efficacy are likely to continually use digital learning spaces (Kuadey *et al.*, 2022). Therefore, the study argues that virtual self-efficacy acts as a decisive moderator between synchronous learning and learner continuous use, as well as asynchronous learning and learner continuous use (see Figure 1). Based on the assertions made, the study hypothesized that:

H4. Virtual self-efficacy moderates between synchronous learning and learner continuous use.

H5. Virtual self-efficacy moderates between asynchronous learning and learner continuous use.

Methodology
Participants and procedure
This study aims to empirically test a hypothesized model linking DLSE, virtual self-efficacy and continuous use of digital learning spaces among learners in IHL in Greater Accra Region, Ghana. Greater Accra Region boasts of several institutions of higher learning such as Ghana Communication Technology University and University of Ghana. The study's target population was learners in IHL within the Greater Accra Region between the months of August 2022 and March 2023. A convenience sampling technique was employed in self-administering a total of 700 questionnaires, and 604 valid responses were retrieved, representing 86.3% response rate. The merits of this technique include ease to respondents' access, as well as willingness and readiness of learners' to voluntarily participate in completing the self-administered questionnaires (Creswell, 2014). Questionnaires were adapted for response gathering to attain the study objectives. All together with five well-trained enumerators, ethical statements such as the guarantee of anonymity and pledge of confidentiality of responses were spelt out to the respondents. The estimated average time for completing the adapted questionnaire was 15 min.

In the preliminary assessment of the dataset, 35 colleges of education students were sampled for a pre-test as proposed by Preneger *et al.* (2014). The researchers posit that a minimum sample of 30 is enough to generate a high power of 80% suitability of a pre-test questionnaire. Further, the pre-tested items revealed Cronbach's alpha values greater than 0.70; accordingly, the pre-tested items were deemed appropriate for further analysis.

Measures
A five-point Likert-type scale with anchors (1) strongly disagree to (5) strongly agree was used to gather responses on all the constructs. Description of the scales are given below.

Digital learning space experience. For this construct, a 10-item scale adapted from Ellis and Goodyear (2016) was used. In this study, DLSE is defined as learners' experience with online and offline interactive tools deployed by IHL. A sample item on the scale is "digital learning is convenient".

Learner continuous use. For this construct, a 3-item scale adapted from Wu and Chen (2017) was used. In this study, LCU is defined as learners' satisfaction and corresponding loyalty to digital learning tools as preferred medium of exchange. A sample item on the scale is "I prefer classes delivered through digital platforms".

Synchronous and asynchronous learning. For this construct, a 10-item scale developed from a review conducted by Fernandez et al. (2022) was used. In this study, SYNL is defined as real-time digital platforms that help learners in engaging with instructors, whereas ASYL is defined as offline and sequence enhanced digital platforms that allow learners to self-schedule and self-regulate digital learning. Sample items on the scale are "the learning environment of real-time digital sessions feel the same as in-person learning sessions", and "I am able to plan my learning schedule effectively".

Virtual self-efficacy. For this construct, a 3-item scale adapted from Tierney and Farmer (2002) was used. In this study, VSE is defined as learners' competency in navigating through digital learning tools effectively. A sample item on the scale is "I use digital tools with ease".

Results

Psychometric properties of measures
Exploratory factor analysis (EFA) was undertaken with an eigenvalue set above 1 for all the scaled items. The recorded EFA scores for all items of DLSE, SYNL, ASYL, VSE and learner continuous met the benchmarked value of 0.07 (Hair et al., 2017). Consequently, learner continuous use had all items loading significantly. On the other hand, DLSE, SYNL, ASYL, VSE and learner continuous use had 18 out 23 items loading adequately. Additionally, robustness of the data (goodness-of-fit) was assessed via an alternate technique to ensure data trustworthiness (Hair et al., 2010) (see Table 1).

Sampling adequacy tests
KMO and Bartlett's test of sphericity constitutes principal estimation methods that are deployed to determine sampling suitability when undertaking EFA. It is desirable that KMO values fall between 0 and 1, for dataset to be reasoned as adequate. Further, acceptability benchmark of Bartlett's test is any value less than 0.05. KMO scores revealed in this study are as follows; DLSE, SYNL, ASYL and VSE (all explanatory variables were grouped) = 0.874 and explained 64.806% of variance in the model. Further, learner continuous use = 0.849 and explained 51.473% of variance in the model. The *p-values* of Bartlett's test of sphericity (*p-value* sig of 0.000 < 0.05) were significant for all variables. Summarily, the dataset was estimated as suitable and appropriate for further analyses (see Table 1).

Reliability, validity and correlation analysis
The study evaluated internal consistency of the research instruments through Cronbach's alpha and composite reliability. Nunnally and Bernstein (1994) established that Cronbach's alpha values must be > 0.70, whereas composite reliability must be > 0.80. Each construct loaded significantly; DLSE = (α 0.898, CR 0.951); SYNL = (α 0.921, CR 0.916); ASYL = (α 0.937, CR 0.950); VSE (α 0.904, CR 0.932) and learner continuous use (α 0.894, CR 0.931). This denotes that all constructs had good reliability and composite reliability (see Table 1).

The dataset's convergent validity was established as all the constructs' average variance extracted (AVE) were greater than the acceptable AVE threshold of 0.5. Also, the dataset's

Factor measurement	Loadings	Variance exp. (%)	R	CR
Learner Continuous Use (α = 0.894)		51.473		0.936
LCU3	0.881		0.894	
LCU1	0.880		0.902	
LCU2	0.793		0.882	
KMO = 0.849, Bartlett's test of sphericity: χ^2 = 5941.331, $p < 0.000$				
Digital Learning Space Experience (α = 0.898)		22.481		0.958
DLSE1	0.901		0.887	
DLSE7	0.863		0.906	
DLSE10	0.857		0.799	
DLSE4	0.819		0.800	
DLSE3	0.749		0.894	
DLSE2	0.741		0.890	
Asynchronous Learning (α = 0.937)		17.453		0.940
ASYL2	0.891		0.922	
ASYL5	0.874		0.888	
ASYL1	0.821		0.898	
ASYL3	0.771		0.886	
ASYL4	0.748		0.898	
Synchronous Learning (α = 0.921)		12.883		
SYNL4	0.831		0.884	
SYNL1	0.818		0.901	
SYNL3	0.731		0.889	
SYNL2	0.729		0.807	
Virtual Self-Efficacy (α = 0.904)		11.989		0.920
VSE1	0.857		0.896	
VSE2	0.844		0.911	
VSE3	0.770		0.880	
KMO = 0.874, Bartlett's test of sphericity: χ^2 = 6793.711, $p < 0.000$				
Source(s): Field survey by authors (2023)				

Table 1. Factor analysis, reliability and composite reliability of constructs

discriminant validity was established as square root of the constructs' AVEs were greater than correlations among the study constructs in the model (Fornell and Larcker, 1981) (see Table 2).

Items	CR	AVE	1	2	3	4	5
Digital Learning Space Experience	0.958	0.679	*0.824*				
Synchronous Learning	0.916	0.606	0.706**	*0.779*			
Asynchronous Learning	0.950	0.677	0.119**	0.193**	*0.823*		
Virtual Self-Efficacy	0.920	0.680	0.089*	0.180**	0.137**	*0.825*	
Learner Continuous Use	0.936	0.726	0.383**	0.410**	0.549**	0.262**	*0.852*
Mean			2.832	2.720	4.019	2.700	3.487
SD			0.782	0.612	0.676	1.220	0.676

Note(s): SD = Standard Deviation, AVE = Average Variance Explained and CR = Composite Reliability. All inter-correlation coefficients are significant at *$p < 0.05$ and **$p < 0.01$. Italics Diagonal figures represent the square root of the AVE; sub-diagonal figures are the latent construct for inter-correlations
Source(s): Field survey by authors (2023)

Table 2. Mean, SD, reliability measures and inter-correlation for constructs

Measurement and structural model
The initial statistics measurement model indices are as follows ($x^2 = 437.817$, $df = 291, p = 0.001$); RMSEA = 0.008; CFI = 0.997; TLI = 0.995 and SRMR = 0.010, indicating good fit of the model.

Demographic characteristics and test of normality
The survey is made up of four demographic characteristics, namely gender, age, type of institution and technological gadget used. Gender was dominated by males with 63.6%. The age range was dominated by 18–27 bracket with 40.4%. Regarding institutional type, 74.3% of the respondents were university students. Finally, 84.8% of the respondents surveyed used mobile phones to access digital learning spaces. Hence forward, descriptive statistics of the mean and standard deviations of the constructs were measured. Kolmogorov–Smirnov and Shapiro–Wilk's test of normality was undertaken to address concerns of the normal distribution of sampled data (Pallant, 2007). The p-values for all the constructs were greater than the α-value of 0.05 (Pallant, 2007); this meant that the data were normally distributed. Multicollinearity was addressed by using only correction coefficients which were not above 0.80 (Hair *et al.*, 2010).

Parallel moderated-mediation model
A parallel multiple mediation model tested whether digital learning space experience was related to learner continuous use through synchronous and asynchronous learning (see Figure 1). First, the study findings reveal that digital learning space experience significantly predicted synchronous learning (b = 0.552, SE = 0.023, t(604) = 24.447, $p < 0.001$), asynchronous learning (b = 0.103, SE = 0.035, t(604) = 2.945, $p < 0.01$) and learner continuous use of digital platforms (b = 0.194, SE = 0.037, t(604) = 5.176, $p < 0.001$), rendering support to H2a and H3a and H1, respectively. Also, asynchronous learning positively predicts learner continuous use (b = 0.264, SE = 0.084, t(604) = 3.158, $p < 0.01$) rendering support to H3b (see Figure 2). However, synchronous learning was not statistically
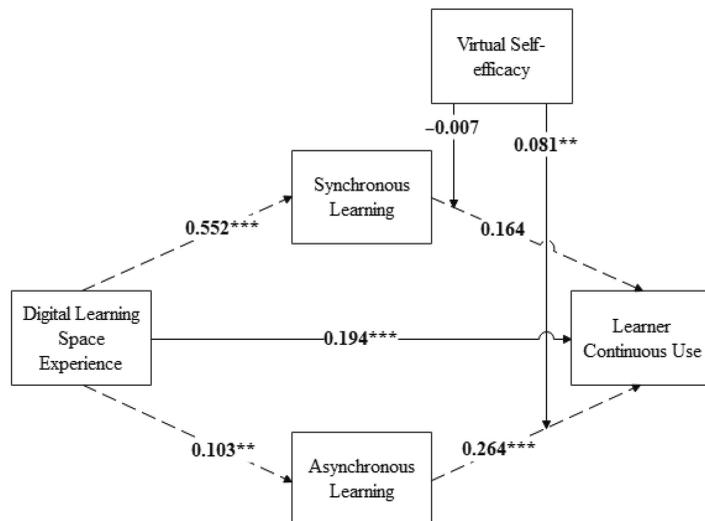

Figure 2.
Tested research model

Source(s): Authors' tested (hypothesized paths) framework (2023)

significant in predicting learner continuous use (b = 0.164, SE = 0.096, t(604) = 1.700, $p > 0.05$), hence H2b was not supported.

Second, the study examines the mediating role of synchronous and asynchronous learning between digital learning space experience and learner continuous use. The mean estimate of the indirect effect of digital learning space experience on learner continuous use through synchronous learning was (b = −0.004, SE = 0.014), with a 95% bias-corrected confidence interval of [LL −0.033, UL 0.024]. Also, the mean estimate of the indirect effect of digital learning space experience on learner continuous use through asynchronous learning was (b = 0.008, SE = 0.005), with a 95% bias-corrected confidence interval of [LL 0.001, UL 0.019]. The study outcome shows that the indirect effect of asynchronous learning was statistically significant. Hence, asynchronous learning was established as a mediator between digital learning space experience and learner continuous use, rendering support to H3. However, the indirect effect of synchronous learning between DLSE and continuous use was not significant; hence, H2 was not supported (see Figure 2).

Third, the study examines the moderating effect of virtual self-efficacy. This statistical analysis is suitable when an outcome variable is a product of interactions among other explanatory variables; for example, Y = X*M. Specifically, the analysis was undertaken to measure the linear, as well as interaction effects of synchronous learning (SYNL) and virtual self-efficacy (VSE), as well as asynchronous learning (ASYL) and virtual self-efficacy (VSE). Accordingly, the interaction term DLSE*ASYL positively predicts the relationship between asynchronous learning and learner continuous use (b = 0.081, SE = 0.030, t(604) = 2.715, $p < 0.01$) rendering support to H5 (see Figure 2). However, the interaction term DLSE*SYNL was not statistically significant in predicting the relationship between synchronous learning and learner continuous use (b = −0.007, SE = 0.029, t(604) = −0.247, $p > 0.05$); thus, H4 was not supported. Further, the conditional and total effects from DLSE to learner continuous use were tested against specific moderator values of virtual self-efficacy ($M \pm 1\ SD$) (see Table 3). The study outcomes show that 2 out of 3 indirect effects were significant within $\pm 1\ SD$. This indicates that the prediction of learner continuous use by synchronous learning is possible within the VSE range of M ± 1 SD and that the indirect effect from DLSE to learner continuous use is higher for respondents with lower virtual self-efficacy values but not significant to respondents with higher virtual self-efficacy. Also, the study outcomes show that all indirect effects were significant within $\pm 1\ SD$. This indicates that the prediction of learner continuous use by asynchronous learning is possible within the VSE range of M ± 1 SD and that the indirect effect from DLSE to learner continuous use is higher for respondents with lower virtual self-efficacy values compared to respondents with higher virtual self-efficacy scores (see Table 3).

Synchronous learning	b	BootSE	BootLLCI	BootULCI
−1 SD	0.086	0.039	0.010	0.164
M	0.078	0.033	0.012	0.140
+1 SD	0.075	0.038	−0.003	0.024
Asynchronous Learning				
−1 SD	0.036	0.015	0.007	0.067
M	0.052	0.021	0.011	0.094
+1 SD	0.060	0.025	0.013	0.111

Note(s): BootLLCI and BootULCI = Lower level and upper level of the bias-corrected and accelerated bootstrapped confidence interval for = 95%; bootstrapping resamples $N = 5,000$
Source(s): Field survey by authors (2023)

Table 3.
Indirect effects of digital learning space experience on learner continuous use via synchronous and asynchronous learning at ±1 SD of the virtual self-efficacy (N = 604)

Discussion and conclusion of findings

This research investigates direct and indirect effects between DLSE (Digital Learning Space Experience), synchronous and asynchronous learning, as well as continuous use among students in IHL in Ghana. The findings show that DLSE has a significant and positive link with learner continuous use. This implies that the deployment of digital spaces for learning directly and positively influences learners' attitudes. The outcome resonates with other empirical findings which have plausible explanation that if DLS experience is good, learners' will develop a positive attitude towards continuous use (Duggal, 2022; Maslov *et al.*, 2021). Also, the study outcome explains that DLSE brings education closer to learners through offerings such as self-administration of schedules, ease of access and convenience. These attributes account for adoption and continuous use of digital technologies among learners in Ghanaian IHL. Given this, it is concluded that DLSE contributes to learner continuous use.

Also, DLSE was found to be a positive predictor of synchronous learning among learners in Ghanaian IHLs. This implies that digital learning space experiences are enhanced through real-time media tools, such as zoom video conferencing among learners. The finding infers that learners' general feeling about digital space learning is enriched when audio-visual tools are deployed in real-time. This feature makes virtual learning environments similar to traditional or in-person sessions (Racheva, 2018). The finding confirms that digital learning spaces offer augmented features that have the capacity to boost overall adoption, appreciation and use of technology within learning environments. Similarly, the study outcome reveals that DLSE positively predicts asynchronous learning among learners in Ghanaian IHLs. This implies that DLS experiences are enriched by offline digital features, which enables learners to conveniently self-administer and self-schedule their own means of learning. Further, asynchronous learning gives students the opportunity to learn in episodes, thereby reducing information overload (Ritter *et al.*, 2007).

Next, the statistical effect of synchronous learning on learner continuous use was found to be significant and positive. This finding corroborates outcomes of prior studies undertaken by Al-Sharafi *et al.* (2023), as well as Alajmi and Said Ali (2022), where the studies established a positive association between synchronous learning and learner continuous use of real-time digital tools. Separately, both studies highlight the importance of real-time functionalities of synchronous learning and how these functionalities help arouse desires of learners to continuously use digital learning spaces. Hence, learners with good experiences with real-time virtual tools are likely to continually prefer this mode of delivery. Similarly, asynchronous learning was established to have a positive effect on learner continuous use. This outcome is in consonance with other empirical findings conducted by O'loughlin and Griffith (2020), as well as Rivers (2021), where the studies argue that asynchronous learning is flexibly structured, hence can be deployed at any stage of the educational ladder. Further, asynchronous learning provides opportunity for learners to succinctly document aspects of a digital session, thereby helping develop their metacognition. Therefore, the provision of augmented virtual functionalities may help learners embrace continuous use of digital learning spaces.

The first mediation hypothesis showed that synchronous learning was not a significant mediator between DLSE and learner continuous use. The finding denotes that real-time digital offerings do not sufficiently explain links between DLSE and continuous use in the current study. Conversely, this outcome does not corroborate prior empirical findings undertaken by Bervell *et al.* (2020), as well as Lin *et al.* (2022), where these studies argue that real-time interactions between educators and learners is a key determinant of learner continuous use of digital spaces. Inability of synchronous learning to mediate between DLSE and learner continuous use in the study could be explained from a theoretical stance of SDT, where learner intrinsic motivation is deemed as prerequisite for continuous use of digital learning spaces (Ganotice *et al.*, 2023). Further, the continuous use of real-time tools may be

hindered by Internet cost and network challenges particularly among rural learners (Shen *et al.*, 2022). The second mediation hypothesis showed that asynchronous learning significantly mediates between DLSE and learner continuous use. The finding denotes that asynchronous learning sufficiently explains the relationship between DLSE and continuous use. The finding highlights that learners' digital space experience and continuous use could be given meaning by episode learning and opportunity for metacognitive skills development. This outcome corroborates prior empirical findings undertaken by Ajayi (2010), as well as Wei *et al.* (2023), where the studies argue that discussion boards and metacognitive strategies act as indirect links between digital learning spaces and learner attitudes. Capacity of asynchronous learning to mediate between DLSE and learner continuous use in the study is grounded in the SIT. SIT posits that the development of learning episodes and sequences are vital in the determination of digital learning efficiency (Ritter *et al.*, 2007).

Regarding the moderation effect, the finding explains that interaction term "DLSE*VSE" does not significantly moderate the effect between synchronous learning and leaner continuous use. This outcome is not in consonance with findings obtained in prior related studies, where VSE as moderator was established on learner outcomes in synchronous learning environments (Mushtaque *et al.*, 2022; Peltier *et al.*, 2022). Thus, it is argued that the incapacity of DLSE*VSE to substantially moderate between synchronous learning and learner continuous use could be explained by limited motivation of learners to use real-time digital tools. A number of factors may account for limited motivation to use real-time tools by learners in Ghanaian IHL. These factors include; live streaming network challenges and information overload due to long instructor-learner sessions (Rizvi and Nabi, 2021). Also, the study outcomes reveal that interaction term "DLSE*VSE" significantly moderate between asynchronous learning and leaner continuous use. This finding corroborates outcomes of related prior studies, where VSE as moderator was established on learner outcomes in asynchronous learning environments (Alghamdi *et al.*, 2020; Rivers, 2021). Therefore, it is reasoned that the capacity of DLSE*VSE to substantially moderate between asynchronous learning and learner continuous use could be explained by learners' flexibility in scheduling classes, capacity to perform mental scripting and application of self-questioning in digital learning spaces (Desai and Chin, 2020).

Theoretical and practical implications

The paper made a number of theoretical and practical recommendations. First, the paper theoretically projects the relevance of DLSE, synchronous and asynchronous learning, virtual self-efficacy and learner continuous use through both the self-determination and spacing and interleaving theoretical lenses. Second, the study makes significant contribution to the higher education literature by jointly examining digital structural elements and learners' psychological issues in the digital transformation process. Accordingly, the current study extends literature on digital transformation in education by combining the assumptions of SDT and SIT as a prerequisite for learner continuous use of digital learning spaces.

Practically, the findings of the study are expected to be used as a blueprint for analyses and considerations of determinants of continuous use of digital learning spaces in IHL. Educational managers in universities and colleges should acquire or build technological infrastructure to help promote self-inspired learning among students. Finally, it is imperative to state that online education is still at a nascent stage, hence there is a need to encourage both educational managers and students to embrace a blended approach in pedagogical delivery.

Limitations and areas for future study

Notwithstanding a number of noteworthy implications spelt out in this study, there are some methodological limitations prompting a need for future studies to explore. First, this study was only undertaken in the context of learners within IHL who used digital learning spaces within the Greater Accra Region of Ghana. Based on this sampling scope, generalization of the study outcomes is constrained. Future studies could expand the sample size to cover wide-range of geographical scope. Second, the current study was guided by a positivist paradigm, hence the study only examined inferential statistics among the study constructs. The study recommends future inquiries to explore deeper understanding of the phenomenon from an interpretivist's perspective.

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