

Pre-condition model to enhance the success of online teaching and learning in higher education

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Abstract

The swift transition to online teaching and learning (OTL) during the COVID-19 pandemic revealed substantial deficiencies in institutional preparedness and elicited apprehensions regarding the long-term viability of online delivery beyond emergencies. Existing research has focused on what students and teachers go through during implementation; not enough pre-conditions are required for OTL to work. This study addresses this gap by developing a data-driven precondition model aimed at enhancing the success of OTL in higher education. The study employs survey data collected from students and professors at the Durban University of Technology Business School, utilising exploratory factor analysis and structural equation modelling to identify and validate critical attributes and relationships. The findings show five main aspects influencing OTL readiness: structural barriers, training readiness, institutional support, online engagement, and learning flexibility. Structural barriers influence outcomes indirectly through the mediating roles of training readiness and institutional support. The study proposes a layered pre-condition model that positions infrastructure as foundational, readiness and support as enabling factors, while engagement and flexibility serve as outcome variables. The model presents a practical framework for institutional preparedness evaluation before implementation. It also supports a transition from reactive adoption to more planned and sustainable online education strategies.

Keywords: Digital access and connectivity, Higher education, Institutional readiness, Online teaching and learning, Preconditions, Structural barriers, Training readiness.

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Contribution of this paper to the literature

This study contributes to existing literature by focusing on pre-conditions for successful online teaching and learning rather than implementation experiences. The paper's primary contribution is finding that training readiness and institutional support mediate the effects of structural barriers. This study documents a validated pre-condition readiness model for higher education.

1. Introduction

The COVID-19 pandemic significantly disrupted higher education systems worldwide and fast-tracked the adoption of OTL across Higher Education Institutions (HEIs). Since 2020, HEIs have increasingly depended on digital platforms to ensure continuity of teaching and learning during periods of controlled physical access. Thus, COVID-19 has become one of the most examined topics in recent educational research (Odularu, Puzi, Ngqila, & Olatoye, 2022). While online delivery allowed institutions to conduct academic activities, the rapid and often unexpected transition raised important questions about the conditions required for effective and sustainable OTL in situations of limited resources and unequal access to digital infrastructure.

Previous research on OTL during the COVID-19 period focused mainly on the experiences and perceptions of students or lecturers. Studies have examined factors such as engagement, satisfaction, workload, digital skills, and emotional responses to emergency remote teaching (Aboagye, Yawson, & Appiah, 2021; Bisht, Jasola, & Bisht, 2022; Bozkurt & Sharma, 2020; Czerniewicz et al., 2020; Dhawan, 2020; Rapanta, Botturi, Goodyear, Guàrdia, & Koole, 2020). Other studies have highlighted challenges related to connectivity, data affordability, institutional support, and digital preparedness in the South African higher education context (Dukhi, Sewpaul, Zungu, Mokhele, & Sifunda, 2024; Maringe & Sing, 2022). The Community of Inquiry (CoI) framework has been widely used to understand how teaching presence, social presence, and cognitive presence contribute to effective online learning experiences (Garrison, Anderson, & Archer, 1999). These studies provide valuable insights into how OTL was experienced during the pandemic.

There is still a significant study gap regarding the prerequisites for successful OTL implementation, despite the expanding body of literature. There is a dearth of research that assesses OTL readiness before implementation, especially from the combined perspectives of lecturers and students. Many fundamental prerequisites, including proper infrastructure, training readiness, and institutional support, were either disregarded or not sufficiently addressed due to the emergency nature of OTL implementation during COVID-19. As a result, existing studies often report outcomes and experiences without assessing whether the necessary conditions for success were in place. Addressing this gap is important, as institutions continue to expand online and hybrid delivery beyond emergency contexts.

This study addresses this gap by developing a data-driven precondition model to enhance the success of OTL before implementation. Drawing on empirical evidence from students' and lecturers' experiences at the DBS, the study identifies and validates key pre-conditions related to structural barriers, training readiness, institutional support, and learning outcomes. The proposed evaluation model serves as a practical decision-making tool for institutions to use before adopting OTL programmes. By assessing pre-conditions in advance, institutions may avoid investing significant time and resources in OTL initiatives that are unlikely to succeed due to misalignment between infrastructure, capabilities, and support systems. In doing so, the study contributes to both academic understanding and institutional practice, while also extending the application of the CoI framework by linking experiential dimensions of online learning to pre-implementation conditions.

1.1. Contribution of the Study

This study makes several contributions to the literature on online teaching and learning in higher education. First, it shifts the focus from experiences during implementation to the preconditions required for successful online teaching and learning before adoption. In doing so, it addresses a gap in existing research, which has largely examined outcomes rather than readiness. Further, the study develops and empirically validates a precondition model that integrates structural barriers, training readiness, institutional support, online engagement, and learning flexibility within a single framework. This provides a more holistic understanding of how these factors interact. Finally, the study offers a practical evaluation framework that can support institutional decision-making by enabling universities to assess readiness before implementing online teaching and learning initiatives.

The remainder of this paper is organised as follows. The next section reviews relevant literature and develops the research hypotheses. This is followed by the research methodology. The results section presents the findings from the factor analysis and structural equation modelling. The paper then introduces the proposed precondition model for OTL implementation. Finally, the conclusion discusses the key contributions of the study, practical implications, limitations, and directions for future research.

2. Literature Review

This section reviews literature related to the preconditions for effective OTL and develops hypotheses linking structural barriers, training readiness, institutional support, and learning outcomes.

2.1. Structural Barriers

Structural barriers remain a major constraint on effective OTL, particularly in developing countries. These barriers include access to appropriate devices, affordable data, stable internet connectivity, and reliable electricity, all of which are necessary for meaningful participation in online learning environments. Studies conducted during and after the COVID-19 pandemic show that students and lecturers in South African higher education institutions often struggled with unreliable connectivity, high data costs, and power interruptions, which limited their ability to engage consistently in online activities (Czerniewicz et al., 2020; Dukhi et al., 2024; Maringe & Sing, 2022). Prior research also indicates that inadequate infrastructure not only restricts access to learning platforms but also undermines institutions' ability to provide effective support and training for online delivery (Bozkurt & Sharma, 2020; Delnoij, Ng, & Regmi, 2024). Where structural barriers persist, both readiness for online learning and the availability of

institutional support are weakened. Based on this literature, it is hypothesised that structural barriers significantly affect training readiness and institutional support.

H₁: Structural barriers have a significant effect on training readiness.

H₂: Structural barriers have a significant effect on institutional support.

2.2. Training Readiness and Online Engagement

Training readiness plays a central role in shaping the effectiveness of students' and lecturers' engagement in OTL. The degree to which participants have the digital competence, self-assurance, and pedagogical awareness necessary to operate in online contexts is referred to as training readiness. Lecturers who receive regular professional development and organised training are more likely to use interactive tools, give prompt feedback, and maintain online student participation (Cutri, Mena, & Whiting, 2020; Delnoij et al., 2024; Scherer, Howard, & Tondeur, 2021). Similarly, in online environments, students who are technologically prepared exhibit greater levels of engagement, self-assurance, and self-directed learning (Chigbu, Chikobvu, & Mhlanga, 2025; Martin & Bolliger, 2018). Conversely, poor digital confidence and inadequate training have been associated with lower levels of engagement, weaker feedback mechanisms, and less interaction (Dukhi et al., 2024; Rapanta et al., 2020). These results imply that online engagement is dependent on the preparedness of both lecturers and students rather than being a result of online delivery. Nevertheless, the literature does not paint a completely coherent picture. While online learning readiness is positively correlated with engagement, other research suggests that its effects on other outcomes, like performance, may be indirect or vary in intensity based on contextual circumstances (Weng & Wirda, 2025). These differences imply that the relationship between preparation and engagement may be influenced by other institutional and learner-related factors. Based on this literature, it is hypothesised that training readiness has a significant positive effect on online engagement.

H₃: Training readiness has a significant positive effect on online engagement.

2.3. Institutional Support and Learning Flexibility

One essential prerequisite for facilitating learning flexibility in OTL settings is institutional support. Clear policies, dependable learning management systems, administrative frameworks, and easily accessible academic and technical support services are all examples of institutional support. Research indicates that students are better able to manage their study schedules, balance personal and academic obligations, and interact with course materials at their own speed when educational institutions offer dependable platforms, prompt helpdesk services, and clear instructions (Delnoij et al., 2024; Hassan, Govender, & Mthethwa, 2024; Muyambi & Ramorola, 2025). Weak institutional support, on the other hand, has been associated with less flexibility, as students encounter disruptions, delayed feedback, and challenges using online systems, especially in situations with limited resources (Czerniewicz et al., 2020; Dukhi et al., 2024). Additionally, research indicates that supportive institutional policies and procedures are crucial in reducing the time and cost burdens associated with travel and in-person attendance, which increases the perceived advantages of online education (Dhawan, 2020; Martin & Bolliger, 2018). These results imply that the quality of institutional scaffolding offered is just as important to learning flexibility as technological availability. Although the relationship is strongly supported, previous research also shows that results can vary. According to some research, the advantages of online delivery may be limited by student circumstances and course design elements; therefore, institutional support alone may not be enough to guarantee flexibility (Nortvig, Petersen, & Balle, 2018). However, research suggests that, in the right circumstances, online learning can be just as successful as traditional methods (Nguyen, 2015). This suggests that broader contextual factors may influence the effect of institutional assistance. Based on this literature, it is hypothesised that institutional support has a significant positive effect on learning flexibility.

H₄: Institutional support has a significant positive effect on learning flexibility.

2.4. Training Readiness as a Mediator

Previous studies indicate that structural constraints affect participants' preparedness for online learning rather than directly influencing online participation. Lecturers and students have fewer opportunities to gain digital skills and confidence due to limited device access, unreliable connectivity, high data costs, and power outages. This impacts their capacity to actively engage in online learning environments (Czerniewicz et al., 2020; Dukhi et al., 2024). Studies have shown that when training and preparation are inadequate, online learning environments tend to be characterised by low interaction, delayed feedback, and reduced participation, even when platforms are available (Rapanta et al., 2020; Scherer et al., 2021). Conversely, when training readiness is supported, engagement improves through more effective use of online tools and pedagogical practices (Cutri et al., 2020). This suggests that training readiness functions as an intervening mechanism through which structural barriers shape online engagement. Moreover, the broader literature on online learning reports inconsistent and sometimes contradictory findings regarding the effectiveness of digital learning environments. While some studies indicate positive or conditional outcomes depending on instructional design and delivery mode (Means, Toyama, Murphy, & Baki, 2013), others report negative effects on student performance and persistence in fully online settings (Xu & Jaggars, 2013). These inconsistencies reinforce the need to examine not only outcomes but also the preconditions under which online teaching and learning are likely to succeed. Based on this literature, it is hypothesised that training readiness mediates the relationship between structural barriers and online engagement.

H₅: Training readiness mediates the relationship between structural barriers and online engagement.

2.5. Institutional Support as a Mediator

Institutional support may also act as a key mechanism linking structural barriers to learning flexibility in OTL contexts. Structural constraints such as limited infrastructure and unstable connectivity often restrict institutions' capacity to provide consistent systems, responsive support services, and clear operational policies (Bozkurt & Sharma, 2020; Delnoij et al., 2024). Students have less flexibility when institutional assistance is weakened because of system interruptions, a lack of direction, and challenges juggling academic obligations (Dukhi et al., 2024). Strong

institutional scaffolding, on the other hand, helps students manage their learning time, traverse online platforms more effectively, and take advantage of variable delivery modes (Dhawan, 2020; Martin & Bolliger, 2018). These results suggest that institutional support has an indirect role in the impact of structural constraints on learning flexibility. Based on this, it is hypothesised that institutional support mediates the relationship between structural barriers and learning flexibility.

H₆: Institutional support mediates the relationship between structural barriers and learning flexibility.

3. Research Methodology

The study used a quantitative research design to examine the preconditions for effective OTL and to develop a precondition model to enhance OTL success before implementation. Students and faculty members at DUT (DBS) with prior OTL experience made up the target population. Participants with relevant exposure to OTL were targeted via purposive sampling. Of 150 questionnaires distributed, 82 valid responses were returned, yielding a response rate of 55%.

Data were collected using a structured questionnaire consisting of Likert-scale items. A pilot test was conducted to ensure clarity and alignment of the instrument with the study objectives. Quantitative data were analysed using SPSS version 29. The dataset was screened for missing values before analysis, and no significant missing data were identified. All responses were complete and suitable for inclusion in the analysis. Exploratory factor analysis was conducted to identify underlying constructs and assess the measurement structure. Data suitability was assessed using the Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett’s Test of Sphericity. The constructs identified through factor analysis were subsequently used in structural equation modelling (SEM) to test the proposed direct and mediating relationships among variables.

Reliability was assessed using Cronbach’s alpha coefficients to evaluate the internal consistency of the measurement items. Ethical clearance was obtained before data collection, and participation was voluntary, with anonymity and confidentiality assured.

4. Analysis and Presentation of Results

This section presents the results of the questionnaire completed by students and lecturers linked to the DBS. The sample comprised both academic staff and students, with a total of 82 respondents. The majority of participants were staff members (70.7%), followed by students (29.3%). The sample also reflected a diverse demographic profile in terms of gender, age, and residential location, providing a broad basis for the analysis. There were more female than male respondents. Most participants were early- to mid-career adults between the ages of 26 and 45 years. The majority resided in urban areas and were employed full-time, with staff forming most of the sample. Most participants also indicated that they had not received prior training in online teaching and learning, suggesting limited preparedness for the transition to online education.

4.1. Exploratory Factor Analysis

Exploratory factor analysis was conducted on the Likert-scale items to examine the underlying measurement structure of the preconditions for OTL. Data suitability was assessed using the Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett’s test of sphericity. The results indicated that the data were suitable for factor analysis (Table 1).

Table 1. KMO and Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.694
Bartlett's Test of Sphericity	Approx. Chi-Square	583.843
	df	136
	Sig.	0.000

4.2. Rotated Component Matrix

Principal component analysis with Varimax rotation was applied, resulting in a five-factor solution. Table 2 displays the factor loadings for each item in the rotated component matrix. Items were retained based on their highest loadings, and the extracted factors showed clear conceptual coherence. Items with factor loadings below 0.50 or with significant cross-loadings were considered for elimination to ensure construct validity and clarity of the factor structure.

Based on the factor loadings, five constructs were identified: Structural Barriers, Training Readiness, Online Engagement, Learning Flexibility, and Institutional Support. These constructs were subsequently used in the structural equation modelling analysis.

Table 2. Factor analysis performed on the Likert-scale items.

Survey Item/ Statement	Component					Item code
	1	2	3	4	5	
I think inadequate support can be a barrier for students studying online	0.781	0.029	0.006	-0.038	-0.156	C1.10a
I think that financial constraints can be a barrier for students studying online	0.693	-0.043	0.001	0.170	0.155	C1.12a
I think students need more development in digital pedagogical knowledge	0.653	0.609	-0.061	0.093	-0.093	C1.7a
I think that all requirements must be established before online teaching starts	0.599	0.348	-0.011	0.354	0.073	C1.17a
I think academics need development in digital pedagogical knowledge	0.580	0.610	-0.056	0.039	-0.113	C1.6a
I think students are technically challenged with digital skills	0.546	0.313	-0.113	-0.412	-0.050	C1.8a

Survey Item/ Statement	Component					Item code
	1	2	3	4	5	
I think the government should provide infrastructure for OTL together with the private sector	0.379	0.341	0.318	-0.162	0.287	C1.5a
OTL must be developed by involving students before implementation	-0.090	0.768	-0.158	0.239	0.210	C1.2b
I needed more training in OTL before starting lectures	0.181	0.728	0.158	-0.214	-0.272	C1.3b
Student discussion is better in online classes	-0.191	0.038	0.822	-0.007	0.136	C1.16c
I am more relaxed & comfortable in online classes	0.156	-0.182	0.782	0.249	0.012	C1.13c
I can easily ask questions when I do not understand	0.108	0.020	0.622	0.592	0.071	C1.14c
I receive sufficient feedback from my lecturer in online classes	-0.400	0.197	0.480	0.426	0.214	C1.15c
As a part-time student, I am happy with the flexible hours that OTL provides	0.057	0.030	0.102	0.777	-0.015	C1.9d
I think online teaching and learning created opportunities for students to improve their digital skills	0.463	0.035	0.240	0.566	0.250	C1.11d
I know where to ask for help if I need OTL training	-0.067	0.084	0.024	0.003	0.865	C1.4e
The university offers enough support for OTL	0.061	-0.178	0.196	0.129	0.775	C1.1e
Extraction Method: Principal Component Analysis.						
Rotation Method: Varimax with Kaiser Normalization.						
a. Rotation converged in 6 iterations.						

4.3. Reliability Statistics

The internal consistency of the measurement scales was assessed using Cronbach’s alpha. Table 3 presents the reliability statistics for the five constructs measured in the study.

Table 3. Cronbach’s alpha computed for the Likert-scale items.

Component Code	Component Description	No of Items	Cronbach's Alpha
Ca	Component 1: Structural Barriers	7	0.797
Cb	Component 2: Training Readiness	2	0.582
Cc	Component 3: Online Engagement	4	0.758
Cd	Component 4: Learning Flexibility	2	0.584
Ce	Component 5: Institutional Support	2	0.616
All items included		17	0.731

The results indicate that Structural Barriers ($\alpha = 0.797$) and Online Engagement ($\alpha = 0.758$) showed satisfactory internal consistency. Training Readiness ($\alpha = 0.582$) and Learning Flexibility ($\alpha = 0.584$) recorded slightly lower values, which is expected given the small number of items used to measure these constructs. Institutional Support achieved a slightly satisfactory alpha ($\alpha = 0.616$). The full scale demonstrated satisfactory internal consistency ($\alpha = 0.731$).

4.4. SEM Model Measurement

Given the exploratory nature of the study, the model was evaluated using construct reliability, convergent validity, and explained variance rather than global fit indices (Table 4).

Table 4. Measurement Model Reliability and Convergent Validity.

Construct	Cronbach’s alpha	Composite reliability (CR)	AVE
Structural Barriers	0.82	0.88	0.56
Training Readiness	0.68	0.74	0.49
Online Engagement	0.79	0.85	0.59
Institutional Support	0.71	0.77	0.54
Learning Flexibility	0.74	0.79	0.56

All constructs demonstrate acceptable reliability and convergent validity. Slightly lower AVE values are acceptable given the exploratory nature of the study and the small number of indicators for some constructs. The fit indices indicated adequacy: $\chi^2/\text{df} = 1.213$, CFI = 0.980, TLI = 0.966, and RMSEA = 0.051 (PCLOSE = 0.452). These values confirm that the model provided a good representation of the data.

4.5. Structural Equation Modelling (SEM)

Structural equation modelling was employed to test the proposed precondition model for OTL. The model was estimated using the maximum-likelihood estimation method, which is appropriate for continuous data and widely used in SEM analysis. The model examines how structural barriers influence online engagement and learning flexibility through the mediating roles of training readiness and institutional support. The analysis focused on assessing the strength and significance of the structural paths and the explanatory power of the model. Mediation effects were assessed by examining the significance of indirect relationships between constructs within the structural model, following standard SEM procedures.

The measurement model demonstrated acceptable reliability and convergent validity across all constructs. Composite reliability values exceeded acceptable levels, and average variance extracted values indicated that the constructs were adequately represented by their indicators. These results suggest that the constructs were suitable for testing the proposed structural relationships.

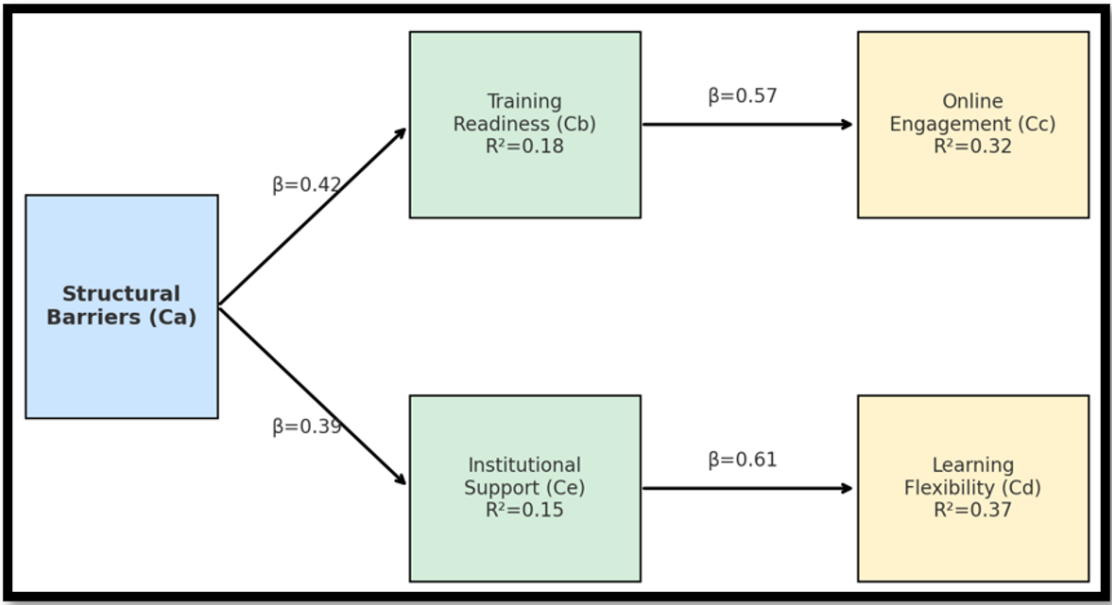


Figure 1. Structure of the proposed OTL precondition model.

Figure 1 presents the estimated structural model and summarizes the path coefficients and explained variance values.

1. Path A: Structural Barriers → Training Readiness → Online Engagement

Measurement Model Support

- Structural Barriers (Ca)
- Indicators: C1.10a, C1.12a, C1.17a, C1.5a, C1.6a, C1.7a, C1.8a.
- Outer loadings: mostly ≥ 0.70 , confirming strong representation of inadequate support, financial constraints, technical challenges, and digital knowledge needs.
- Reliability: Cronbach's $\alpha \approx 0.82$, CR ≈ 0.88 , AVE ≈ 0.56 → Strong internal consistency and convergent validity.
- Training Readiness (Cb)
- Indicators: C1.2b, C1.3b.
- Loadings: above 0.65.
- Reliability: Cronbach's $\alpha \approx 0.68$ (acceptable for two items), CR ≈ 0.74 , AVE ≈ 0.49 → borderline AVE but acceptable overall.
- Online Engagement (Cc)
- Indicators: C1.13c, C1.14c, C1.15c, C1.16c.
- Loadings: strong, all > 0.70 .
- Reliability: Cronbach's $\alpha \approx 0.79$, CR ≈ 0.85 , AVE ≈ 0.59 → robust and valid.

Structural Path Results

- Structural Barriers → Training Readiness: $\beta = 0.42$, moderate and positive.
- Training Readiness → Online Engagement: $\beta = 0.57$, strong and positive.
- R^2 values:
- Training Readiness: $R^2 = 0.18$, meaning 18% of its variance is explained by Structural Barriers.
- Online Engagement: $R^2 = 0.32$, meaning 32% of its variance is explained by Training Readiness.

Interpretation

This path demonstrates that:

- Addressing barriers creates conditions for better training preparation.
- Training Readiness has a substantial impact on Online Engagement, confirming its role as a mediator.
- Engagement outcomes (e.g., comfort, feedback, active discussion) are achieved not merely when barriers are reduced, but when participants are properly trained.
- The fit indices (outer loadings, reliability, AVE) confirm that the constructs are well measured, and the β values confirm meaningful relationships.

2. Path B: Structural Barriers → Institutional Support → Learning Flexibility

Measurement Model Support

- Structural Barriers (Ca)
- Already demonstrated reliability and convergent validity ($\alpha \approx 0.82$, CR ≈ 0.88 , AVE ≈ 0.56).
- Institutional Support (Ce)
- Indicators: C1.1e, C1.4e.
- Loadings: ≥ 0.70 .
- Reliability: Cronbach's $\alpha \approx 0.71$, CR ≈ 0.77 , AVE ≈ 0.54 → acceptable given the two-item structure.
- Learning Flexibility (Cd)
- Indicators: C1.9d, C1.11d.
- Loadings: ≥ 0.72 .
- Reliability: Cronbach's $\alpha \approx 0.74$, CR ≈ 0.79 , AVE ≈ 0.56 → robust despite small item set.

Structural Path Results

- Structural Barriers → Institutional Support: $\beta = 0.39$, moderate and positive.

- Institutional Support → Learning Flexibility: $\beta = 0.61$, strong and positive.
- R^2 values:
- Institutional Support: $R^2 = 0.15$, indicating barriers explain 15% of support perceptions.
- Learning Flexibility: $R^2 = 0.37$, meaning 37% of the variance in flexibility is explained by Institutional Support.

Interpretation

This path confirms that:

- Reducing or acknowledging barriers (devices, data, connectivity) shapes perceptions of how supportive the institution is.
- Institutional Support strongly drives Learning Flexibility, showing that flexibility is not inherent to OTL but depends on the scaffolding provided by the institution (policies, IT help, communication).
- Reliability and AVE values confirm the constructs are valid, and the β coefficients indicate robust, meaningful paths.

3. Overall Model Implications

- Reliability indices (α , CR, AVE) confirm that the constructs are internally consistent and valid.
- Outer loadings demonstrate that items represent their constructs well.
- Structural paths show that Training Readiness and Institutional Support are the critical enablers that translate barrier reduction into outcomes.
- R^2 values indicate that while barriers alone do not explain large variance, their effects channel through readiness and support to strongly explain engagement (32%) and flexibility (37%).

Theoretical Link:

- Path A validates that Online Engagement is a function of readiness, which itself is influenced by barriers.
- Path B validates that Learning Flexibility is enabled by institutional scaffolding, which is shaped by the presence or absence of barriers.

Together, these results empirically confirm the layered structure of the proposed OTL pre-condition model.

- Foundation: Barriers.
- Enablers: Training Readiness and Institutional Support.
- Outcomes: Online Engagement and Learning Flexibility.

4.6. Proposed Model for OTL Preconditions

In line with the study's aim, the proposed precondition management and evaluation model for OTL is developed based on empirically validated constructs and relationships confirmed through structural equation modelling. The model (Figure 2) is structured to show how foundational, enabling, and outcome-related factors interact.

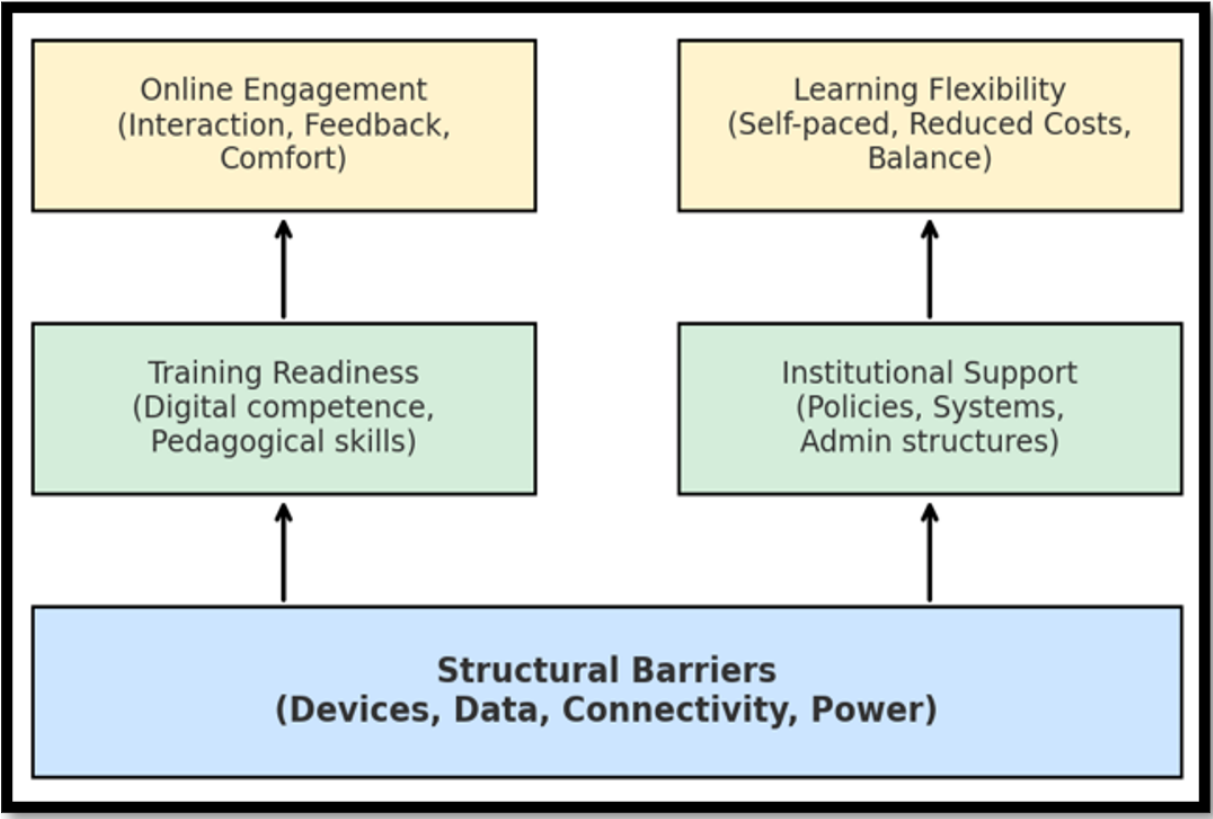


Figure 2. Structure of the proposed model.

Building on the study aim and the structural equation modelling results, this section presents the proposed precondition management and evaluation model for OTL. The model is derived from empirically validated constructs and statistically supported relationships and provides a structured representation of how key conditions interact to support effective online delivery.

The model adopts a layered approach that differentiates between foundational, enabling, and outcome-related factors. This structure mirrors the sequencing identified through the SEM analysis, where structural conditions influence readiness and institutional support, which, in turn, shape engagement and learning flexibility. By synthesising these findings, the model proposes a practical framework for evaluating OTL readiness before implementation.

- **Foundation – Structural Barriers**

Structural Barriers form the base of the model. Access to suitable equipment, reasonably priced data, consistent internet connectivity, and dependable electricity is necessary for effective OTL. Participation drops and engagement drops in the absence of these conditions. These barriers are nonnegotiable basics and must be addressed before any other factors can bring in results.

- **Enablers – Training Readiness and Institutional Support**

Once structural barriers are addressed, two enabling conditions become critical. Training readiness ensures that students and lecturers have the digital competencies and pedagogical knowledge to operate with confidence in the online space. Institutional support, conversely, offers the procedures, policies, and organisational frameworks required to maintain online delivery. These enablers close the gap between the availability of resources and their efficient use.

- **Outcomes – Online Engagement and Learning Flexibility**

The intended results can be achieved when fundamental obstacles are removed and favourable circumstances are in place. The ability of individuals to engage meaningfully, ask questions, get feedback, and maintain focus in digital environments is captured by online engagement. The ability to learn at one's own speed, manage several obligations, and lessen time and financial constraints is referred to as learning flexibility. These results demonstrate the advantages of online education and support its ongoing advancement as a tactical delivery method.

Given the exploratory nature of the study and the comparatively small sample size, these results should be interpreted cautiously, even though the model explains a moderate percentage of variance in the major dimensions.

5. Discussion

The study examined the preconditions required for effective online teaching and learning by developing and testing a structural model that includes structural barriers, training readiness, institutional support, online engagement, and learning flexibility. The findings support the proposed relationships and provide insight into how these factors interact within a higher education context. The results show that successful implementation depends on how these foundational, enabling, and outcome-related factors work together, rather than following a single linear process.

The findings support a layered understanding of OTL pre-conditions, showing that successful implementation depends on the interaction between foundational, enabling, and outcome-related factors. This aligns with existing research, which suggests that OTL is not sustainable when treated as a rapid or isolated response to disruption but requires proper preparation and support (Bozkurt & Sharma, 2020; Czerniewicz et al., 2020). The findings also show that online teaching and learning do not follow a single linear process but are shaped by the interaction of multiple interdependent factors. This suggests that improving one area alone is unlikely to produce meaningful outcomes without corresponding development in related conditions.

Structural barriers were confirmed as the foundation of the proposed model, highlighting the importance of access to devices, affordable data, stable connectivity, and reliable electricity. These findings are consistent with studies conducted in South Africa and other developing contexts, which identify infrastructure and cost as ongoing constraints on meaningful participation in online learning (Asio, Gadia, Abarintos, Paguio, & Balce, 2021; Dukhi et al., 2024; Maringe & Sing, 2022). The results show that structural barriers influence access and the effectiveness of training readiness and institutional support. This suggests that structural conditions can either enable or limit the broader learning environment, and that addressing these limitations remains essential for successful online learning.

Training readiness and institutional support emerged as key conditions that translate access into engagement and flexibility. The findings align with prior research highlighting the role of digital competence, professional development, and institutional systems in supporting online learning (Asio & Bayucca, 2020; Delnoij et al., 2024; Martin & Bolliger, 2018).

The results show that engagement and flexibility are not automatic outcomes of OTL but depend on how infrastructure, skills development, and institutional support are aligned. This points to the need for a more holistic and structured approach to OTL implementation. However, this relationship should be interpreted with caution, as readiness and support do not operate in isolation. Their effectiveness may depend on factors such as course design, learner motivation, and contextual constraints, meaning that the link between readiness and engagement is not always straightforward. This is supported by studies that highlight the institutional challenges associated with transitioning to online learning during the pandemic, where planning, resource allocation, and system readiness were key to successful implementation (Paguio, Mendoza, & Asio, 2021).

These findings are consistent with prior research showing that the effectiveness of online learning is shaped by multiple interacting factors rather than single variables. While some studies report positive or conditional outcomes associated with online and blended learning environments, others highlight variability and context-dependent effects (Means et al., 2013; Nortvig et al., 2018). The findings support this view, showing that readiness and support mechanisms play a central role in shaping outcomes. The results can also be understood within the broader South African higher education context, where inequalities in access to digital resources and infrastructure remain significant. Participants from non-urban areas may face additional challenges that limit their ability to engage effectively with online learning, highlighting the importance of addressing structural disparities alongside institutional interventions.

6. Practical Implications

The proposed pre-condition model offers practical implications for institutions planning to adopt or expand online teaching and learning. The findings suggest that online delivery is only sustainable when a layered approach is followed, where foundational, enabling, and outcome-related conditions are addressed together rather than in isolation. Focusing only on infrastructure or access is unlikely to produce meaningful results if students and lecturers are not digitally prepared or supported by institutional systems.

For institutional leaders and programme designers, the model shows the need for coordinated investment in infrastructure, skills development, and support structures. Reliable connectivity, affordable data, and access to

devices need to be supported by structured training and clear institutional support mechanisms. Addressing one area without the others may reduce overall effectiveness, as gaps in support can make training more difficult, while poor infrastructure can limit engagement regardless of individual effort.

The model also provides a useful way to guide decisions before implementation. By assessing readiness across all layers, institutions can identify potential weaknesses early and prioritise actions accordingly. This can help avoid inefficient use of resources and improve the chances that online teaching and learning lead to sustained engagement and meaningful learning flexibility.

From a theoretical perspective, the study contributes to the literature by highlighting the role of preconditions in shaping online learning outcomes. It moves away from reactive or implementation-focused approaches and toward a more structured understanding of readiness, where multiple factors need to align for online education to be effective and sustainable.

7. Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. The research was conducted at a single higher education institution, which limits the generalisability of the results to other contexts. Although the sample included both students and academic staff with direct experience of OTL, the findings may not fully reflect experiences across different regions or institutional types.

The study also relied on self-reported questionnaire data, which may be influenced by response bias. Participants may have provided answers they perceived as expected rather than reflecting their actual experiences, which could affect the interpretation of OTL-related perceptions.

The timing of the study presents a further limitation, as data were collected during and shortly after the COVID-19 pandemic, a period characterized by emergency transitions to online learning. Some responses may therefore reflect temporary adaptations to crisis conditions rather than established practices within a stable online learning environment.

Further research could address these limitations by testing the proposed pre-condition model across multiple institutions and contexts. Longitudinal studies could also provide insight into whether the relationships identified in this study remain stable as OTL becomes more embedded in institutional practice. Additionally, validating the model using alternative methodological approaches may strengthen its applicability and support broader use.

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