ISSN: 2093-5374 / E-ISSN: 2093-5382

# A Conceptual Framework and Examination of Online Learning Applications Using Software Infrastructure for Pedagogy

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Received: July 26, 2024; Revised: September 06, 2024; Accepted: October 04, 2024; Published: December 30, 2024

## Abstract

Integrating modern technology into teaching is not recent; hence, studies in this field have been conducted over the years. The implementation of Augmented Reality (AR) as a software infrastructure has captured the interest of educators and generated new possibilities in teaching. The advancement of Artificial Intelligence (AI) has enabled educators to adopt innovative approaches and tactics for evaluating and analyzing teaching and learning processes. Learning Analytics (LA) has developed the capacity to revolutionize traditional teaching methodologies through systematic and multifaceted approaches aimed at improving the effectiveness of online education. The study seeks to establish a conceptual framework for expanding online learning, particularly incorporating mobile apps into educational activities. This is accomplished by analyzing the current techniques implemented to improve academic standards via the active application of technology advancements

*Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications (JoWUA),* volume: 15, number: 4 (December), pp. 213-225. DOI: *10.58346/JOWUA.2024.I4.014*

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and the existing frameworks for online learning. The results indicated that incorporating technology gadgets in classrooms is crucial for pupils to succeed, highlighting the imperative for exemplary educators to adjust to digital innovations and prepare learners for opportunities in the changing digital environment. The study contended that successful curriculum implementation requires a synthesis of technical advancement and business platform modification as essential mechanisms for achieving worldwide educational sustainability.

**Keywords:** Conceptual Framework, Pedagogy, Online Learning, Education, Software Infrastructure.

# 1 Introduction

In contemporary circumstances, alongside the inclination to use information and communication technology throughout various domains, their implementation in schooling is progressively expanding (Arkorful et al., 2021). This mainly stems from the necessity for contemporary pedagogical methods and the pursuit of enhanced efficiency in elevating the societal significance of educational organizations' operations (Criollo-C et al., 2021). The enterprise needs personnel possessing the knowledge, skills, and competencies to fulfill the demands of the changing social context. The contemporary educational landscape must facilitate cooperative and individual endeavors for educators and learners according to their needs, capabilities, and preferences (Umarova et al., 2024). Learners should be able to grasp the constantly growing body of information more readily—all of the needs above the modernization of conventional educational techniques (He et al., 2021).

Recent computer improvements have enhanced the efficacy of educational materials for educators and professionals, facilitating the collection and analysis of extensive digital datasets. A suggested way to examine these subjects is by collecting and studying big data, which is handled using Machine Learning (ML) algorithms (Sanusi et al., 2023) and Educational Data Mining (EDM) methods (Charitopoulos et al., 2020). Learning Analytics (LA) (Banihashem et al., 2022) is an emerging topic that has shown significant growth over the past five years, aiming to aid scholars and educators in comprehending learners' requirements through the systematic and autonomous collection and interpretation of large-scale information. The fundamental principle of LA is on learners, whose digital interactions are documented, evaluated, and examined to uncover insights about their cognitive processes and behavioral choices.

Research focuses on enhancing the services of Massive Online Open Courses (MOOCs) (Ceron et al., 2020). Certain scholars have developed review tools and analytical processes for the relationships between pupils and educators to facilitate reflection on implemented teaching tactics (Jeganathan et al., 2024). Recent research investigated multimodal information obtained from devices and mobile devices to deliver adaptive and improved student feedback. Despite a growing demand for evidence-based training, the initiatives to implement learning analytics approaches in Augmented Reality (AR)-enhanced teaching must be more extensive (Garzón, 2021).

This study introduces a bioecological paradigm for student involvement to inform and support subsequent studies on this intricate subject (Hernández et al., 2024). The model encompasses factors affecting pupil participation at the macro, exo, meso, and micro stages, emphasizing the microsystem - the learner's immediate educational setting – as here is where professionals exercise the most effect. Subsequent suggestions are offered on how professionals can apply the framework and its potential to enhance practice.

## 2 Background

For over 20 years, the primary focus of active efforts has been the application and utilization of data and communication technology in learning, the advancement of online learning, and the evolution of online learning. Studies evaluated approaches and structures for online learning that evolve with technological advancements (Bernacki et al., 2020). The incorporation of Artificial Intelligence (AI) in this domain is starting gradually. As cloud technology advances, studies have begun utilizing mobile cloud teaching to enhance oral, visual, and practice-oriented pedagogical techniques.

Implementing online learning systems started with the online learning Shell (Derakhshan et al., 2021). The system and the requisite hardware are accessible to all public colleges. Technological advancement has resulted in the increased utilization of the Moodle platform. Some institutions utilize alternative systems such as Blackboard. All institutions are undertaking substantial initiatives to update information and communication technology. This indicates a solid foundation for advancing online learning inside the classroom. Examples of online learning technologies created include eFLAGMAN (Bernacki et al., 2020), which facilitates foreign language acquisition via mobile gadgets, and PeU 2.0 (Plovdiv Electronic Universities) (Lederman et al., 2021), a modern platform for designing, implementing, and maintaining virtual educational environments (Kurbanazarova et al., 2024).

The advancement of online learning is associated with several issues categorized into technological, methodical, and personnel-related categories (Leminen et al., 2022). The technological problems pertain to gadgets and interaction difficulties in addition to those concerning the course material itself. Due to technological advancements, these issues have mostly been resolved. Concerning the methodological problems, strategies are being explored to integrate the new form of communication into the comprehensive educational process (Trullàs et al., 2022). In practice, personnel-related issues are the most critical. Educators must often independently acquire knowledge of emerging technologies, incorporate them into the educational process, encourage learners to utilize these possibilities, and ultimately provide high-quality instructional content (Wu, 2024).

Criollo-C et al., have examined the obstacles to online learning inclusion in educational institutions across Africa (Criollo-C et al., 2021). Technical assistance must be extended to learners and teachers regarding the utilization of mobile technology. Learning administration systems must be intended to be appropriate for mobile gadgets. Training ought to be given to course builders, and connectivity to the internet across educational institutions, such as learner residences, classrooms, and libraries, should be enhanced.

Investigations into online learning in colleges and universities have resulted in the initiation of Online Learning in Higher Education (Aljawarneh, 2020), which seeks to enhance the utilization of mobile technologies in this sector and foster the advancement of pedagogical and learning frameworks. The initiative offers training for instructors and students, facilitating their engagement with new technology.

Students ought to be inspired to engage in the learning process with the enthusiasm they exhibit towards computer games, social media, and internet usage (Demirkiran & Tansu Hocanin, 2021). Interaction and social contact are fundamental elements that enhance the appeal of games. An effective strategy is to incorporate them into teaching as well. Learners in higher education in developing nations predominantly utilize online learning gadgets to supplement online learning. Contemporary smart mobile gadgets provide various online learning resources through smartphone apps, portals, online connections, infrared light, and Bluetooth broadcasts (Ruzibaeva et al., 2024). A team of academics from the College of Informatics at the University of Economics - studies performed a survey in late 2021 with 110 learners registered in the Faculty of Information Technology (Moskova et al., 2022).

The findings indicate that all participants possess mobile gadgets in the subsequent ratio: 60% own two mobile gadgets, 25% possess three, and 15% have one mobile device. Ninety-four percent own high-speed internet access on their mobile phones or tablets. Seventy-three percent of pupils utilize online learning programs (Jabbar & Kareem, 2022). Ninety-one percent of the learners possess expertise using the university's online learning technology (Asukile et al., 2022). The research indicates that pupils own mobile gadgets and Internet access. The institution provides complimentary Wi-Fi access in all three facilities. The online learning system is situated on a rented cloud-based server. The technical problems associated with online learning deployment, outlined at the outset of this study, related to gadgets and interactions, have mostly been resolved. The circumstances are analogous in the majority of higher education organizations.

# 3 Proposed Conceptual Framework for Online Learning

The suggested structure comprises four primary elements: design, development, evaluation, and validation. All components are part of a continuous cyclical process modified to meet current demands. The comprehensive structure of the suggested structure is illustrated in Figure 1. The proposed structure will assist and enlighten teachers, teachers, and data analytics on the design, execution, and assessment of LA in the classroom. It will offer guidance for using this structure in AR-supported pedagogical innovations.

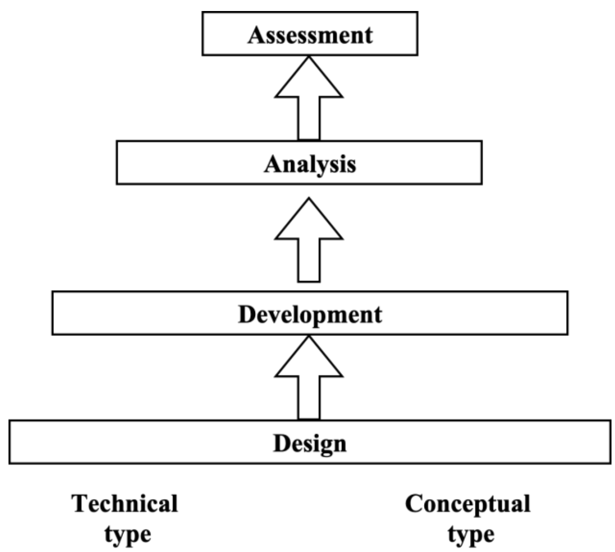


Figure 1: Workflow of the Suggested Framework

## 3.1. Design

The design of any procedural procedure is essential since it influences its effects and the significance of the findings. A well-structured procedure will deliver secure and unambiguous scientific outcomes to the participating stakeholders, facilitating their utilization by the broader scientific field. A well-designed LA procedure might yield deceptive or contentious results and lead to a loss of productive hours. The research asserts that significant attention must be directed to the correct layout of the LA procedure. Drawing from relevant studies on LA and learning design methodologies, the suggested structure delineates comprehensive guidelines by segmenting the designing process into seven discrete phases divided into two categories (i.e., technological and conceptual) that investigators ought to adhere to develop a successful LA usage for educational purposes.

### 3.2. Development

This constitutes the second element of the suggested structure. It encompasses all the tasks investigators must undertake to further the investigation. All modifications required for the learning system or the server are implemented inside this element. Developers must create novel instruments, apps, and software essential for the investigation. AR apps could be more helpful in documenting statistics. Programmers must modify the AR program and framework that administers the instructional material and augmentations. Upon completing this element, investigators should possess the requisite programs and tools necessary for the subsequent element (evaluation).

### 3.3. Evaluation

In the analysis phase, researchers must meticulously evaluate the data by the conclusions of the design phase, utilizing the programs and instruments produced in the preceding element. They should adhere to optimal procedures informed by the layout of the selected analysis. The data research will yield valuable insights for all parties concerned. Scientists must convey this knowledge to stakeholders with appropriate visualization methods. They must additionally furnish explanations of the findings and potential activities the recipients do to better leverage the study's outcomes. For instance, investigators or automated evaluation systems might supply educators with LA outcomes with a supplementary report outlining recommended activities, such as: (a) What measures should be implemented concerning learners? (b) What strategies might be employed to enhance their online classes? Is there a necessity to offer more AR material or collaborative activities?.

### 3.4. Assessment

The final element of the suggested structure is to enhance learning analytics methodologies and outcomes. Researchers must evaluate the quality of the generated data, the used sample, and any particular attributes, including the application of AR or instructional tools and other concerns pertinent to the conducted study. They must document any constraints or deficiencies and suggest potential enhancements to the LA procedure. This move will enable scientists to enhance the LA procedure over time, yielding improved outcomes. Based on the LA findings, they can enhance the implemented pedagogy (including instructional approaches and concepts), the delivered educational material, or modern technologies (such as AR) in the educational program.

### 3.5. AR-supported Interventions

The suggested architecture applies to any LA application. This section offers recommendations and outlines the implementation of the proposed framework for pedagogical AR-supported innovations. Figure 2 illustrates a learning AR intervention for the present case study, comprising three primary measurements: pedagogy, instructional content, and technologies.

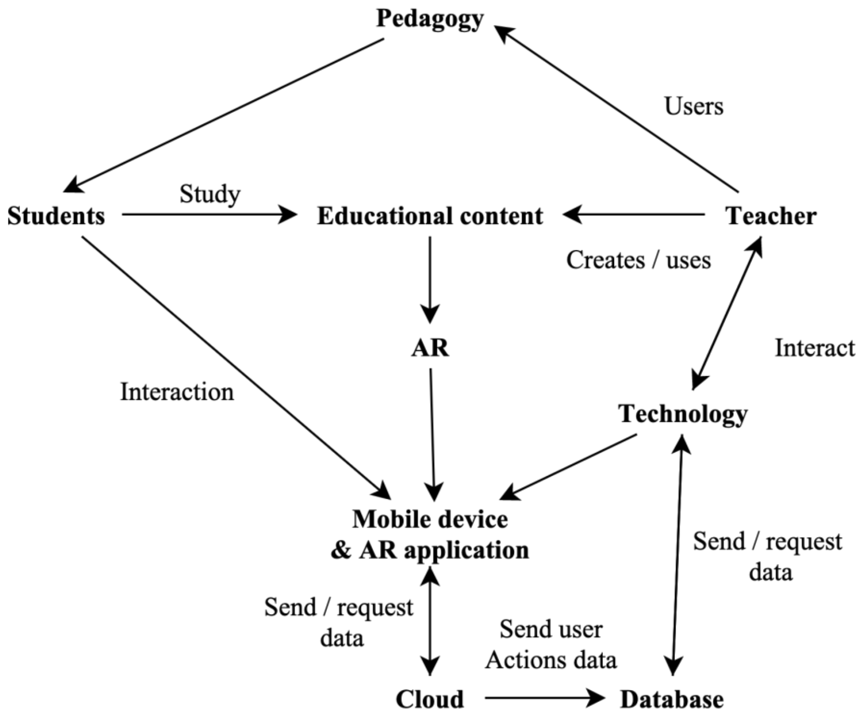


Figure 2: AR-based Online Learning Intervention Framework

The teacher first outlines the approach for the educational measure and the employed pedagogy, including instructional scenarios, strategies, and learning concepts. The teacher generates or supplies students with designated educational materials in either conventional (documents, observations, etc.) or electronic (PDF, PowerPoint, etc.) designs, which are then utilized through an AR utilization that enables learners to "augment" the original educational material with relevant additional details.

Learners have a link to instructional materials and utilize their mobile gadgets (smartphones, tablets, AR spectacles, headphones) to engage with enhancements and the material. All learner actions are recorded in an external repository. This data can serve as input for the LA procedure. The teacher adheres to the outlined framework stages, constructs the LA utilization, employs technology for its creation aspect (if required), and then analyzes the information collected by the design aspect's results. The teacher evaluates the quality of the generated outcomes and suggests enhancements to the learning analytics process, pedagogical methods, instructional material, and AR application.

### 3.6. Conceptual Framework

This study proposes a theoretical framework for online learning growth in higher education organizations grounded in active strategy directives for higher educational advancement objectives and targets. The intended strategies for advancing education include using data and communication technology.

- The technical support for students.
- Learners are considerably familiar with mobile gadgets and online learning resources.
- The examination of the investigated systems for online education.

Figure 3 illustrates the primary components of the suggested architecture.

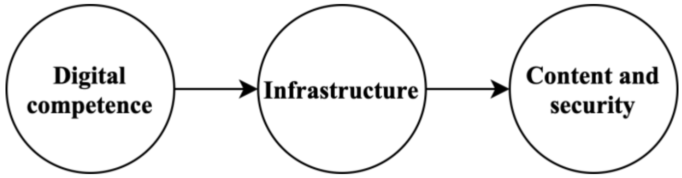


Figure 3: Primary Components of the Conceptual Framework

Figure 4 illustrates a more comprehensive representation of the conceptual framework for online learning growth in colleges and universities. It provides a comprehensive overview of the paths in which all stakeholders' activities should be focused while linking these goals to the essential criteria critical for effective online learning growth.

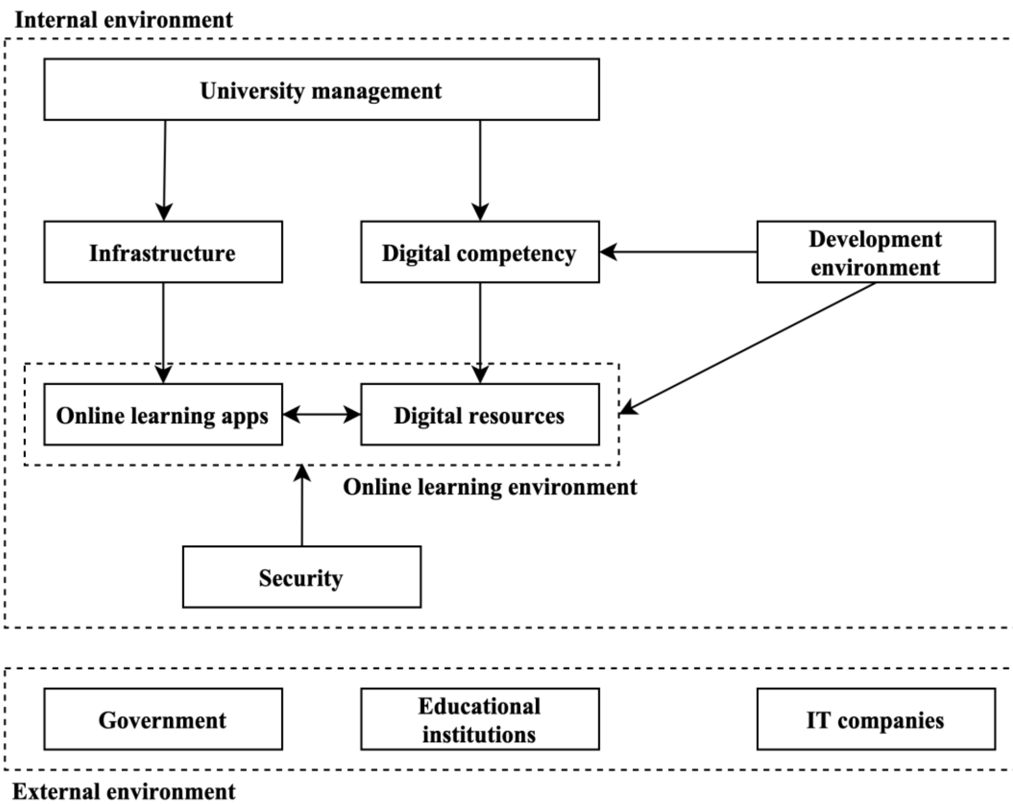


Figure 4: Internal and External Environment of Conceptual Framework

The framework aligns with the specific characteristics of the schooling system. It highlights the deficiencies in the existing circumstances that hinder the attainment of effective online learning. The epidemic and the subsequent state declaration of emergency have required a complete transition to online learning. The change has demonstrated that the deficiencies outlined in the study persist and that the recommended structure is necessary.

Significant potential exists for the advancement of online learning. Information about using study substances, programs, and student outcomes is examined using suitable methods. In light of the outcomes acquired, measures must be implemented to enhance and advance the learning procedure. Selecting a data extraction and analysis program depends on capability, integration possibilities with current software, and price. No optimal strategy applies to all scenarios that guarantee an equally favorable outcome.

# 4 Findings and Discussions

## 4.1. Outcomes

Using technology to augment student participation can result in various short-term and long-term educational and social results, referred to as proximal and distal repercussions (Figure 5). Short-term effects encompass augmented discipline-specific expertise and advanced cognitive abilities, heightened inspiration, a better feeling of community and well-being, and strengthened connections facilitated by peer-to-peer instruction and teamwork. Long-term results encompass continuous learning, augmented personal growth, and heightened participation in the broader educational society.

**Short term outcomes**

| Academic | Social |
|---|---|
| Knowledge | Satisfaction |
| Attitude | Competence |
| Skills | Wellbeing |
| Interests | Relationships |
| Technical confidence | Collaboration |
| Study habits | Involvement |
| | Teamwork |
| | Interpersonal skills |

**Long term outcomes**

| Academic | Social |
|---|---|
| Retention | Citizenship |
| Work success | Personal growth |
| Lifelong learning | Involvement in institution |

Figure 5: Short-term and Long-term Outcome Analysis

## 4.2. Student Engagement

This paradigm illustrates the interaction between the AR, learner participation, and results (Figure 6). It represents the notion of learner engagement previously stated, wherein engagement is affected by several internal and external circumstances. Increased student participation and empowerment within the learning community significantly enhance the likelihood of achieving various objectives, which fosters a reciprocal relationship where this enthusiasm, exertion, and involvement reinvigorate the activities and learning atmosphere.

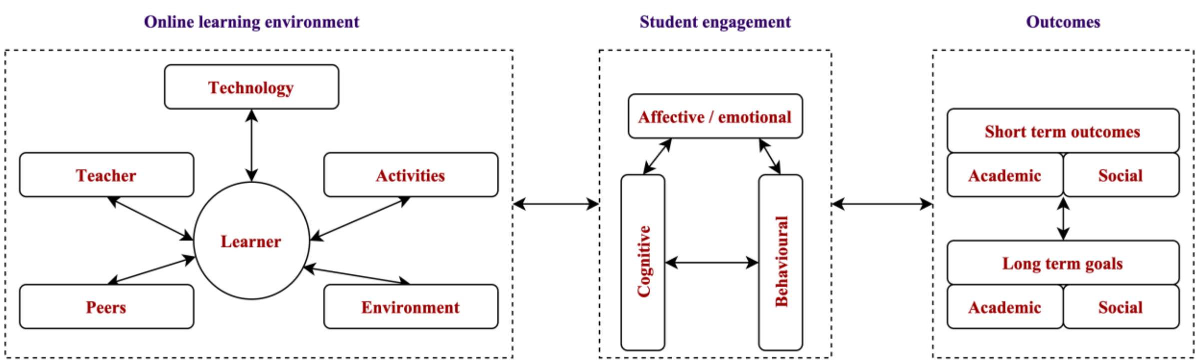


Figure 6: Relationship between Online Learning, Student Engagement, and Outcomes

### 4.3. Implications

Digital competence and skill acquisition are essential abilities in the digital era. This study advances the utilization of AR technology in educational research in several respects: (a) It offers an ongoing structure that emphasizes the paramount significance of utilizing AR for enhancing students' abilities, and (b) it offers a comprehensive insight into the assessment of these digital abilities through LA measures.

The research strongly advises instructional technologists to concentrate on creating and implementing AR training courses to strengthen trainees' digital capabilities and improve their learning outcomes. The programs' user interface must be straightforward yet provide intelligent "fading scaffolding" activities per the teachers' instructions. From the teacher's perspective, essential strategies include project, activity, and problem-oriented classrooms that enhance trainees' practical efficiency and can be employed by teachers to cultivate esteemed educational and disciplinary procedures across various academic domains. The subsequent consequences for behavior and policy have been suggested:

- Instructional developers must receive training in using relevant software and equipment related to AR technological devices.
- Implementation programmers and learning technicians should investigate design remedies for implementing AR technological advances in experiential learning methodologies.
- Politicians should pay attention to the socio-cognitive and cultural implications of employing dynamic AR programs in conjunction with LA to educate students and professionals regarding their efficiency and results.

## 5 Conclusion

Online learning education presents several opportunities for enhancement, development, progress, and the broadening of education and learning outside conventional classroom environments. The primary challenge confronting online learning is the matter of security and long-term investment. Advancements in technology perpetually accelerate progress across all domains. Particular effort must be directed into higher education, which cultivates future experts. They must possess the information, abilities, and competencies pertinent to the actual requirements of the organization. The instructional material must align with contemporary advancements in the relevant subject area while being understandable to students and consistent with their current academic level. This study addressed a pertinent topic by presenting a conceptual framework for integrating new technologies (AR and LA) in traditional and informal educational environments. The suggested conceptual design, grounded in an academic design framework, can aid educators, teachers, and researchers in exploring possible relationships and difficulties within educational practices, taking into account a variety of instructional situations, available assets, and design features of academic endeavors. LA methodologies can improve the educational continuum by implementing different instructional and evaluation strategies.

Irrespective of the environment and the technologies employed, the instructor's involvement remains essential, particularly for guiding and evaluation processes. Instructors and educators must be trained to proficiently facilitate designing and implementing dynamic and engaging corporate and educational experiences. While the suggested framework broadly applies to planning, creating, and executing AR-supported lessons for students and professionals seeking to apply theoretical understanding in immersive settings to enhance learning, the incorporation of LA presents various managerial challenges regarding confidentiality and morality. This is especially crucial for trainees with diverse socio-cognitive experiences, health issues, or intellectual impairments, necessitating informed permission.

This model, while merely one perspective on this intricate phenomenon, provides a coherent conceptual framework that benefits investigators, educators, policy consultants, and professionals, potentially guiding future studies on student involvement. Future research should address the factors associated with assessing instructional methods for educating learners with learning challenges or impairments. Educators must ascertain whether kids require exceptional help and supervision due to challenges. It would be advantageous to investigate educators' viewpoints, preferably within the framework of longitudinal research, about the paths and migrations from transitory online learning environments to the anticipated blended educational system in the future.

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