



# Forging a learner-centric blended-learning framework via an adaptive content-based architecture

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## ABSTRACT

The covid-19 pandemic was reported with significant negative impact on global education with shocks that disrupted the learning processes via the closure of traditional classrooms/schools from 2020 to March 2022. These effects have continued to ripple across even with advances in media literacy. The Nigerian frontier has also witnessed a paradigm shift in the adoption/integration of the information and communication tech as tools for both digital revolution and advancement of alternative education delivery. Today's education which aspires for growth and progressive development is assured of positive changes if priority for educational values and ICT is harnessed. Past educational theories seem not to cope with the ever-changing, information society. Nigeria must develop strategies to address education reforms with frameworks to bridge these gaps vid post covid-19 era. Our study implements a hybrid a(synchronous) learning framework for Nigerian Tertiary education. Result shows improved learner cognition, engaged qualitative learning, and a learning scenario that ensures a power shift in the educational structure that will further equip learners to become knowledge producer, help teachers to emancipate students academically, in a framework that measures quality of engaged student's learning.

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## 1. Introduction

Learning is the acquisition of knowledge and skills that are stored in memory overtime as well as having it readily available for prompt access to help resolve challenges and explore opportunities [1]. Learning is a lifelong modification in the behaviour of a system, or an alteration within the capability of that system to behave in a certain or given fashion [2]. While, there exists many definitions to describe

learning – its deliverables therein, is geared towards and/or targeted at the same outcome (i.e. learning yields an alteration or change in a system). These changes are often a result of new knowledge, new understanding, new skills and values, preferences and attitude as acquired in the course of undertaking a task that essentially improves the overall experience and performance of the system [3], [4] – and having such new data readily available for future use in different cases or similar scenario [5], [6].

A learner's way of processing data is his/her cognition style; And, it relates the learner's capability to acknowledge and acquire new data, process and represents such data by mapping them onto his cognitive domain as patterns for ease in memory recall. This is because, learning is a 2-phase art that consists of reception (which involves the recognition of new facts or knowledge) and processing (which involves mapping or representation of these new facts onto memory to aid recall) [7]. In the quest for education – learning involves style(s) appropriate with the reasoning capabilities innate of the various learners. Dominic and Francis [8] developed an e-learning ensemble and framework in which the authors classified learners into groups, and proposed corresponding inventories and methods – using the Sarasin model. Their results showed that learners were classified into three (3) groups based on their learning styles namely: (a) visual learners who gain new facts and knowledge via visual inputs, (b) auditory learners who learn simply by listening to a teacher or medium of teaching, and (c) kinesthetic/tactile learners learn through experiments and exploration (using the Montessori means); Though, Hidayat and Utomo [9] noted that Felder-Silverman categorized learning styles into 32-variants such that if/when a teacher becomes aware of these – s(he) becomes more sensitive in designing classroom activities that enhances the teaching-learning process.

A critical issue that needs resolving in the learning process – is to help learners creatively work and contribute to knowledge creation (a hard feat to obtain in traditional schools with classroom settings). The adoption of ICT as means of alternative delivery, has further bolstered and revolutionized the learning process with e-learning (and its variants) to the rescue. E-learning today involves the use of ICT-based services and electronic media-formats that can be replicated within medium that cuts across a variety of platforms in the learning process [8]. While, E-learning continues to proffer its many benefits to education – the covid-19 regime from March 2020 to March 2022, left the global education with negative impacts resulting from: (a) the adoption of social distancing as a method to curb the spread propagation of the pandemic [10], [11], (b) the advocacy for lessened migration of residents from one place to another [12], (c) adoption of nose-masks in public places and in schools [13], and finally, (d) the closure of schools [14]. Studies have reported that shutdown of traditional schools minimized the widespread of the covid-19 pandemic; But, also had significant negative-impact on the learning capabilities of over 1.6Billion learners globally, and that, where such negative effects are not properly handled, may have long-lasting rippled-effects throughout the formation of such students [15]–[17].

## 2. Method

### 2.1. Learning Strategies on the Nigerian Frontier

As earlier noted globally, the response to the pandemic on the closures of school had its varying impacts for both the short-term costs (with a decline in economic activities) and its rippled long-term costs (that resulted in the restricted access to schools' physical infrastructure for learning, increased learning inequality and losses due to stratifications in access to Internet, learning disparities resulting from widespread digital revolution in regions, increased inefficiencies with harder teacher job description,

child psychomotor health, stability and formation adjustments to new realities, and complex new logistics adaptabilities to new realities – and other costs [18]–[20]. On the Nigerian front, reports showed that projected death rates were not as originally evidenced, due to measures such as restricted migration, adoption and enforced use of surgical masks, the immediate closure of schools, and the adoption of media literacy on all fronts [21], [22].

Education, with its primary functions of teaching and learning – has since become an integral part of our culture. Thus, actualizing our current societal goals as well as those of the generations to come, will be a mirage unless we have excellent understanding of science, technology and mathematics (STEM) education. Educational reforms and strategies today, points to STEM as the heritage and hope of mankind – with its mission to ensure that students are scientifically literate to cope with technological changes of the digital revolution. Thus, STEM proffers goals [6] as: (a) trains learner to adjust and imbibe STEM as a culture, (b) provides basic science-tech literacy for everyday living, (c) provide basic skills and attitude to function for technological developments, and (d) stimulate and enhances learners creativity in our society [23], [24].

Learning often occurs within a physical space or environment called a school, which often has various teachers assigned to various classrooms that also seat various learners of varying ages and capabilities. While, the classrooms provides tools that aids teachers to successfully transfer the requisite knowledge to the requisite learners (i.e. technology of educations), the teachers also are often primed and equipped with pedagogical skills, modes and methods (i.e. educational technology) on how teachers transfer the requisite knowledge. With these, teachers successfully engage learners via a formative process of beliefs and social connects, forming inter-relations between varying culture and the various methods, modes or strategies in which learners can learn [25]. Each classroom yields a structure, where learning is organized [26], [27].

There are basically two strategies or design-styles of educational delivery namely [28] :

- The traditional school with its synchronous mode of learning consists of classroom spaces and structures with 3-major components: administrators, teachers and learners [29]. They seek to provide a systemic structure that employs a face-to-face approach, and usually, an oral mode of communication cum discussion(s) that allow teachers pass on knowledge to learners. It allows learners to question learning contents that appears unclear. This mode of learning is often referred to as synchronous mode [30].
- The Asynchronous Learning design is employed as a means of alternative delivery for education. It employs the use of digital revolution and integration of ICT into education (i.e. teaching/learning), and schools. This mode of learning design strategy continues to witness growth in that it advances a delivery scheme and paradigm shift that yields application of constructivism within a technology-rich classrooms and learning content. It seeks a paradigm where learners to become knowledge producers; rather, than knowledge consumers. This learning strategy engages [31], [32], advances and motivates learners to construct new meaning from knowledge and previous concepts, beliefs and culture with strategies to methods that involves media literacy. Thus, asynchronous learning, is more concerned with and attuned to what a learner understands, and what such a learner does with what s(he) understands. It plays down the traditional role of teachers to just facilitators – because, the integration of ICT becomes both the focus of the study (i.e. technological education) and educational support (i.e. educational technology) as in Fig. 1 [8], [33]. Thus, this strategy and learning design is more concerned with what a learner understands and does; rather, than the

teacher's input [34]. Thus, the adoption and use of equipment becomes focus of study (technology education) and educational support (educational technology) [35].

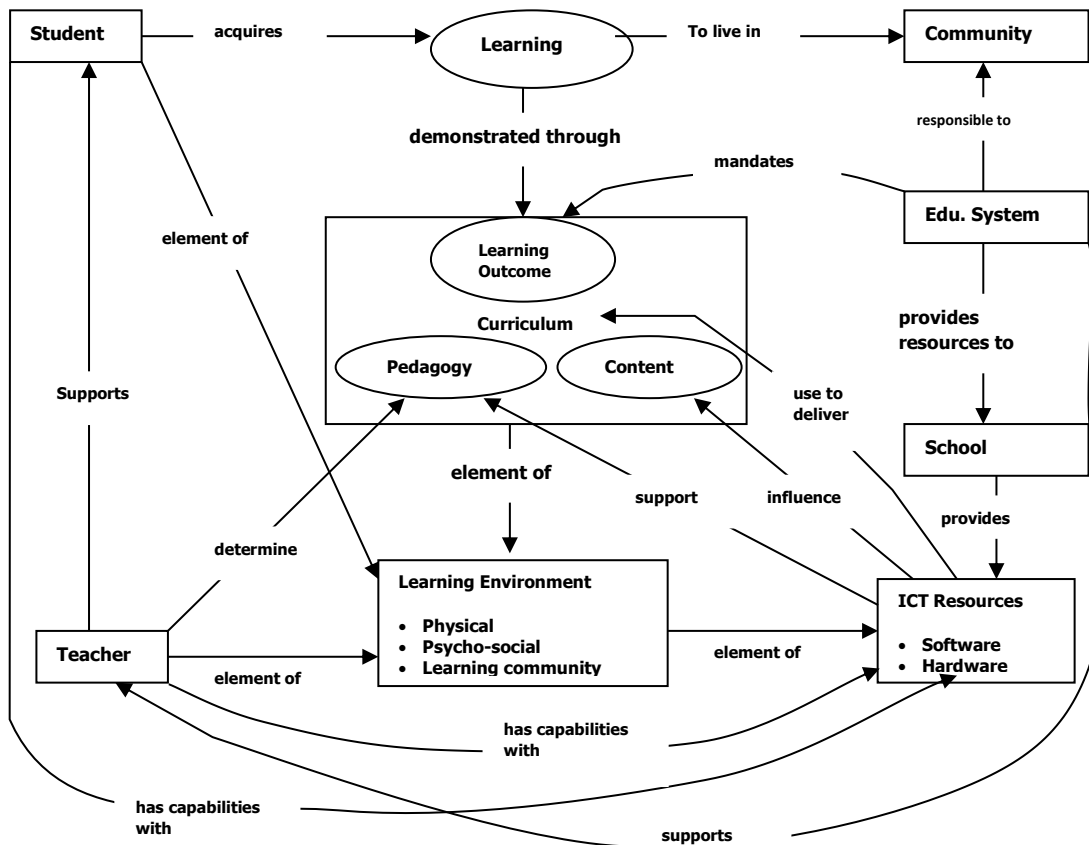


Fig. 1. Relationship between Entities Within the Learning Environment [36]

## 2.2. The ICT-Rich Constructivist Learner-Centric Classroom Design

The pre-and-post covid-19 era witnessed an ever-spiraling increase in alternative delivery, and the development cum deployment of new platforms for improved media literacy in schools and across the various strata of teaching and learning [37]. The technology-rich school/classroom, proposes an educational, teaching and learning space that supports multiple perspectives and descriptions to knowledge construction by the learner via a context-rich and experienced-based set of (systemic) activities [25]. A digitally-equipped school will vary in its level of preparedness, adoption and adaptation, both from the learners and teachers viewpoint. It proffers a myriad of solutions and learning outcomes that harps on a learner's capability, preparedness, flexibility and adaptability to the new norms as requisites to harness the knowledge therein [38]. Also, a learner's capability to retrieve knowledge has high correlation with the level of digital revolution which equips and provisions the school with expanse of printed and electronic versions of materials and sources. Digital revolution in schools yield a paradigm shift with reforms via constructivism [25]. It provides a systemic education that leans on learners to develop critical thinking skills as they become knowledge producers, and leverage on the opportunities of digital revolution [39]. The failures of the traditional school is curbed via the concepts of e-learning of various forms, which is advanced by the critical factor of constructivism, so that learning takes place

as a learner completes tasks for which media support is required and used to maintain such learning environment and learners [40].

Technology creates and support the ideal form of learning environment – poised at a learner-centered scenario with a belief that learners learn more from what they think and do – than from a teacher’s input. Constructivism yields a skill that lets a learner to actively derive knowledge as he learns – emphasizing on knowledge as a construction of the learners mind as a dynamic adaptation towards the interpretation of experiences and realities as the user knows it. Thus, its integration across curriculum, will provides the appropriate level of difficulty due to its tasks that are of real world relevance with engaged-learning and teachers becoming knowledge guides [41]–[43].

E-Learning proffers solution to the perennial constraints of room-space, structured time, and restricted location in the conventional learning with traditional schools. E-learning promises various benefits and alternatives – by helping societies to move toward a vision of life-long and on-demand learning [44]. It refers to the use of ICT to deliver a broad array of solutions that enhance knowledge and performance. It can also called web-based learning, online learning, distributed learning, computer-assisted instruction, or internet-based learning. It broadly defines an ICT-based learning in which learning materials are delivered electronically to remote learners via a computer network. Thus, the Internet becomes the dominant medium of data delivery and knowledge acquisition. The term e-learning can also refer to ICT-enhanced learning that includes the use of web-based teaching materials, hypermedia, multimedia material, websites, discussion boards and forums, computer-aided assessments, digital collaboration, or a combination of all. This learning mode provides access to higher education to teaming learner whom are denied access to conventional universities. With the National Universities Commission (NUC) [45] committed to ensure that Open and Distance Learning (ODL) mode is encouraged in the Nigerian University System (NUS) as alternate to face-to-face mode – and in consonance with the National Policy on Education which has recognized the place of open and distance learning in achieving constant education. A goal of ODL is equitable access to quality education and educational opportunities for less privileged or those who would have been denied. Thus, in spite of NUC’s commitment, only a few Nigerian Universities have fully implemented e-learning and ODL [46], [47].

The progression with E-learning includes mobile-learning, ubiquitous-learning, visual-learning, etc to mention a few. These paradigms are interconnected as variants of E-learning. While, E-learning is a tech-based learning method that employs ICT tools; While, mobile learning is an advanced e-learning where handheld mobile devices are used to access the learning content. Ubiquitous learning is a higher level of learning mode absorbed into e-learning which adds content-sensitive and personalized abilities to e-learning; it also refers to a quiet or pervasive learning [25]. The level of interconnection for these learning paradigms, the variations in their definitions, the requisite software environments for their deployment, and the equipment required for their successful implementation – often varies from one to the other [48]. Some variants of E-learning system available today includes virtual learning (VLE), learning content management system (LCMS), e-learning management systems (e-LMS), and managed learning environ (MLE) etc [40]. The virtual learning management system (VLMS) is a collection of programs (software) designed to use graphics, illustrations, text, sound, videos and other multimedia formats to aid learning; Thus, allows learners to construct new knowledge/meaning from the available knowledge pool. While, some VLMS are open-sourced; Others, are commercially available, and they

include Moodle, Blackboard, Schoology, iSpring Learn, Rippling, Thinkific, TalentLMS, Mindflash, [8] with model as in Fig. 2.

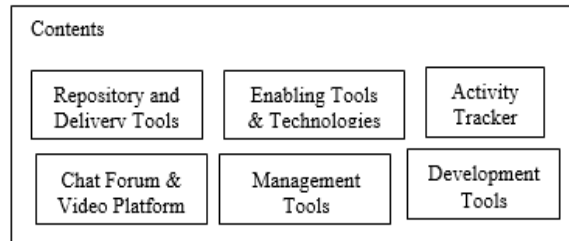


Fig. 2. Entities Relationship for a VLMS [8], [33]

### 2.3. E-Learning Standards

The crux and focal point of the e-learning technologies is the capability to share and have access to e-resources as well as ease for interoperability of the corresponding technologies and interconnected components of the e-learning system. Standards are simply states and conditions that allows for ease of interoperability – making contents within the e-learning system available as we migrate or port from one system to another. Interoperability resolves compatibility issues with systems, and allows for effective function of the software platform with little or no modifications [43], [49]. Thus, interoperability features and components within a system allows for its improved flexibility, adaptability and robustness of the framework and/or application. Some known standards [8], [25] as proposed includes AICC, Dublin Core MetaData Initiative, IMS, ADL, IEEE-LTSC, ARIADNE, LOM, CMI, LTSA, Microsoft LRN, CEN/ISSS WS-LT, Platform and Media Profiles, Architecture and Reference Models LTS, and Prometheus – to mention a few.

### 2.4. Challenges to E-Learning / Study Motivation

The post-covid-19 reports (vis-à-vis the Nigerian experience), has unveiled many challenges to e-learning vis-à-vis its comparison to traditional synchronous learning design and strategy. These challenges include (and not limited to):

- Paradigm Shift in the Educational Strategy – The covid-19 era caught many societies, completely unprepared for the adoption and adaptation of ICT into education globally and in Nigeria (to be more specific). With various adjustments to the educational sector/system, parents and teachers had to switch their roles to facilitators, which they were again – unprepared for [25]. Thus, a major challenge in the adoption of e-learning is the readiness of the current education scenario to utilize as well as harness the benefits therein – of the latest technologies of the web; while and when administrators, teachers and parents are very much obviously, still struggling with the challenges of the previous generations/education. Talk more of, advancing and adapting to the inherent challenges that this paradigm shift portends.
- Global access to Internet: The major merit of e-learning paradigm shift is that it presents learners with access to learning materials and content on-the-go and without discrimination to whoever gets access. However, various post-covid-19 studies [26], [27], [34] have reported that the shutdown of traditional schools that led to the quick adoption of e-learning has continued to experience less privileged control alongside with increased privacy and security risks due to: (a) vastness of the Internet, (b) nature of a variety of e-learning systems deployed, (c) their inherent interoperability etc. These, have continued to stratify and limit global access to these e-learning systems.

- Delivery Outcome on the Learning Setting: The impact of the covid-19 era birthed the sudden need to adapt online teaching/learning, and also challenged the readiness of schools on the paradigm shift to digital revolution readiness. This forced the adoption/adaptation of blended learning (adoption of e-learning that combines two settings of asynchronous and synchronous learning settings). These learning settings differed in time, and the place of teaching/learning activities [50]. But, some of the challenges in the learning setting has been found to include: anonymity and social presence gaps, learning modalities, lower satisfaction, technophobia, lower cognitive achievement, disengaged participation in class of learners, fluency and slower interaction resulting from videoconferencing in e-learning.

## 2.5. Proposed Adaptive Learner-Centric Content-Based Learning Design

We adopt and leverage on the frameworks of Malasowe et al. [24].

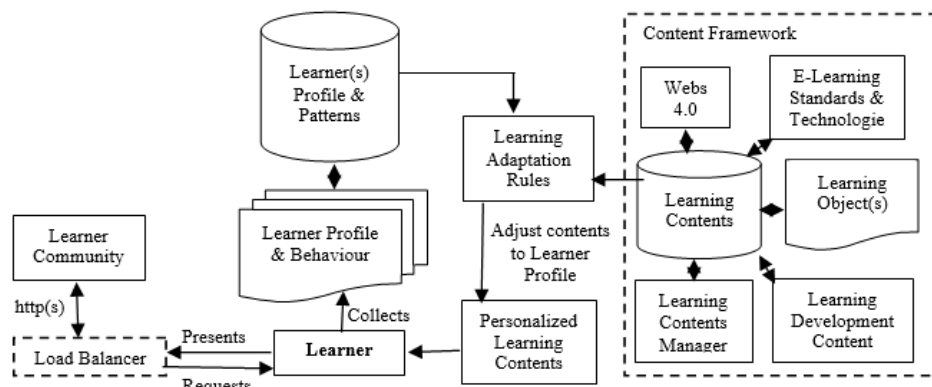


Fig. 3. Experimental architecture for learner-centric design (source: Malasowe et al. [24])

The workings of the ensemble is thus [51] :

- The Learner Profiling Component is that which directly interacts with the learner. It performs the following tasks to include: (a) all the request and response will be through HTTP/HTTPS format, (b) all the request from the learning activity passes through a load balancer which balances the loads based on the proposed data structure and the algorithm, (c) it collects data related to learners' profile and his/her learning behavior; And pass them on to the adaptation model which stores them in a repository to form a pattern and adaptation rules, and (d) it responds back to a learner with the personalized contents provided by the adaptation model.
- The Adaption Component is the main processor for the experimental adaptive e-learning system. It performs these tasks: (a) it stores all learners profiles and their learning patterns into a repository, (b) it simplifies task(s) by responding to each learner, (c) it captures the browsing history, pattern and behavior of a learners, and updates the captured data in its knowledge-base – helping the ensemble keep up with each learner and to transition between the learner profiles, (d) it uses its data content repository (or knowledge-base) about the learners profile to adjust the adaptation rules (and module) for each learner; And thus, identifies the best learning style, learning path and learning contents suited for each identified learner, (e) it builds the personalized learning contents and hands them off to the learners' model to present to a learner, and (f) it retrieves all contents required from the content model.
- The Content Component – performs these tasks: (a) acts a repository for all the learning objects developed by the tutor, (b) ensures that the ensemble's learner-contents is based on the learning

styles ratio as identified in [8], [25], [33], [46] as suggested by the sample population of 40% visual contents, 40 % kinesthetic (do-it-yourself) contents and the remainder 20% audio contents, (c) develop the contents via implementing the latest web technologies and in the scenario, web 4.0 was used to generate the learner contents, and (d) uses the learning content development, management tools, and learning standards to proffer a system that is compatible, portable, can be ported to other systems of varying operating systems, shareable and interoperable with other e-learning systems. The preferred learning contents ranges as thus: (a) visual learning style consists of lecture materials, video lessons, animations, Mindmap, lexicon etc – and, it accounts for 40-percent of learning contents, (b) kinesthetic consists of simulations, online quizzes, discussion forum, online compilations and question banks, which accounts for 40-percent of learning styles, and (c) audio consists of audio materials and accounts for 20-percent of learning styles.

### 3. Results and Discussion

Divayana [33] architecture sought to ensure in e-learning systems – that features such as accountability, quality, public ethics, nationalism etc, where reflected therein. These, he categorized into 10-dimensions, which is supported by Ojugo et al. [52] – whose study recast and refocused participants' interaction with the e-learning system into 9-dimensional items to include: (1) design effectiveness, (2) availability of video conference, (3) CBT readiness, (4) technical support, (5) teacher/learner use of system, (6) availability time, (7) resources reliability, (8) completeness of resources, and (9) data security.

Ananga [10], Borgonovi [12], Divayana [33] and Nilam et al. [23] used Equation 1 to analyze the effectiveness of the learning style(s) used within the learning platform, which compares the learning design percentage effectiveness as the frequency of the subject (F) that chose alternative answers versus the total number of question N. This is categorized into 4-percentiles namely: (a) high category ranges from 81-100%, (b) sufficient category is from 61-80%, (c) moderate category is from 50-60%, and (d) poor category falls below 50%. Both the categories high and sufficient – implies the learning design does not require cum need any form of revision; the category moderate requires some form of revision; while the category poor implies a complete revision of the learning design. Thus, evaluation for both experts and participants yields Table 1 and Table 2 respectively.

$$EP = \left[ \frac{F}{N} \right] * 100 \quad (1)$$

**Table 1.** Experts' Evaluation on the Learning Framework

Features	Experts' Evaluation Scores				
	1	2	3	4	5
Design Effectiveness	0.89	0.96	0.91	0.89	0.92
Availability of Video Conference	0.91	0.87	0.91	0.94	0.89
CBT Integration	0.75	0.89	0.79	0.89	0.91
Technical Support	0.85	0.90	0.92	0.88	0.91
Effective Usage of the Framework by Teacher/Learner	0.92	0.92	0.86	0.85	0.90
Duration & Resumption Capacity	0.91	0.90	0.93	0.98	0.89
Reliability of contents	0.89	0.89	0.78	0.69	0.93
Completeness of resources	0.79	0.91	0.87	0.91	0.96
Data Security	0.76	0.67	0.88	0.95	0.89



Table 1 shows that the framework provides a very high and sufficient category ranges between 80.2%-to-91.6% for evaluated variables by the experts and agrees with [53]–[56]. Its implication therein – is that these components do not require revisions of any kind; However, the data security component ranks at 57.8%, which shows is in the moderate category [57], [58]; And thus, also implies that the effectiveness does require some revision(s). This is in agreement with [59]–[61].

**Table 2.** Participants' Evaluation on the Learning Framework

Features	Participants' Scores		
	$\sigma$	$\mu$	$+Di$
Design Effectiveness	0.27	0.94	0.89
Availability of Video Conference	0.27	0.87	0.89
CBT Integration	0.23	0.82	0.73
Technical Support	0.33	0.90	0.95
Effectives Use by Teacher/Learner	0.28	0.81	0.78
Duration and Reciprocity	0.38	0.81	0.72
Reliability of contents	0.31	0.80	0.86
Completeness of resources	0.29	0.93	0.76
Data Security	0.13	0.85	0.72

Table 2 shows the participant evaluation of the blended-learning ANEKA-based design [62] with mean, standard deviation, and dyadic pairwise relations and interaction between the participants and the system. Its mean interaction values range between 0.80–0.93, which agrees with [63]–[67]. This result of which implies that an effectiveness categorization interaction and use of the e-learning platform ranges from 80-to-93 percent and agrees with [57], [68]–[70]. With a dyadic interaction range of 0.72-0.95. This also implies that the relationship in the interaction between the participants and the e-learning platform cum system ranges from 72%-to-95%.

Education must be actively engage learners with deliverables that include character formation, processing capabilities and improved cognition. Our variant blended-learning has brought about both a paradigm shift and poised to meet the yearnings of a targeted learner-centric design. With parameters such as target survey, qualification, social presence, gender and domicile – it leans on specialized learning path (combining these parameters) as need arises [28], [29], [62], [66]. The proposed ensemble satisfies all objectives for e-learning design strategies namely: attend, apprehend, express, investigate, explore, experiment, discuss, articulate, debate, practice, general conceptualization, construct, and applied in the e-learning system as thus: visual (40%), audio (20%) and kinesthetic (40%). The proposed design advances an individualized learning path as in figure 4 via its various components.

#### 4. Conclusion

To reposition education as a key integral facet of the society as recovery strategies against the impacts of the covid-19 pandemic [58] – requires strong policies, which will yield unexpected high-end results. And though, the impact in Nigeria (on a grander-scale) was not as projected – the shocks, disruptions caused and experienced with the post covid-19 reports, still raises importance with educational and socio-economic policies to help with national recovery. The questions raised therein must answer as reflected upon [71], the local realities vis-à-vis the implementation of platforms to exchange ideas and experiences that fosters effective strategies to help repair the wreckage impacted on the society, and to mitigate

future pandemic spreads of any kind [2], [23], [72]. The framework is implemented as stand-alone on a campus-based Intranet design that will curb the issues of privileged control as well as security risks that comes with its access via the Internet. This intranet-based design mode will also curb the issues of interoperability. The personalized delivery outcome on the e-learning setting seeks to minimize the effects of anonymity and social presence gaps, advances an improved learner satisfaction with the tailored content delivery, improved cognition, and better engaged participation in class of learners.

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