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Designing a Digital Support System for Enhancing Learning Engagement in Computer Studies: A Design Science Research Approach for Nigerian Secondary School

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Abstract **Original Research Article**

The integration of digital technologies into education has transformed teaching and learning worldwide, yet many Nigerian secondary schools continue to experience limited learner engagement in Computer Studies due to inadequate instructional resources, overcrowded classrooms, insufficient computer facilities, and the predominance of teacher-centred instructional methods. These challenges reduce students' opportunities for practical learning and weaken the development of digital literacy skills required in the twenty-first century. Existing digital learning platforms often provide generic instructional support and are rarely designed to address the contextual realities of Computer Studies education in Nigerian secondary schools.This study adopts the Design Science Research (DSR) methodology to design a digital support system that enhances students' behavioural, cognitive, and emotional engagement in Computer Studies. Following the Design Science Research framework proposed by Hevner et al. (2004) and Peffers et al. (2007), the study identifies the educational problem, derives design objectives from existing literature, develops a context-specific digital learning artifact, and proposes an evaluation strategy for assessing its effectiveness in real classroom settings. The proposed artifact integrates five instructional modules comprising interactive learning content, virtual demonstrations, formative assessment, learning progress monitoring, and feedback and communication mechanisms. The system is grounded in Constructivist Learning Theory, Self-Determination Theory, Cognitive Theory of Multimedia Learning, and Activity Theory, ensuring that pedagogical principles are embedded within the system architecture. Unlike many existing educational applications that focus primarily on content delivery, the proposed system is designed to support continuous learner interaction, personalized learning experiences, and practical skill acquisition within resource-constrained educational environments. The study contributes to both educational technology and information systems research by presenting a context-aware digital learning artifact specifically designed for Computer Studies instruction in Nigerian secondary schools. The proposed framework provides a practical model for improving learner engagement while offering researchers and policymakers a scalable approach for supporting digital literacy development in developing countries.

Keywords: Design Science Research, Digital Support System, Learning Engagement, Computer Studies, Educational Technology, Digital Literacy, Nigerian Secondary Schools.

1. Introduction

The rapid advancement of information and communication technologies has fundamentally transformed educational practices across the world. Digital technologies have altered how learners access information, communicate, collaborate, and acquire knowledge, thereby redefining traditional classroom instruction. Educational institutions increasingly integrate digital platforms, interactive learning environments, multimedia technologies, and intelligent learning systems into teaching to improve learning outcomes and prepare students for participation in an increasingly digital society. Consequently, digital learning is no longer viewed as a supplementary instructional strategy but as an essential component of contemporary education.

The global transition towards digital education became even more pronounced following the COVID-19 pandemic, during which schools and universities adopted online and blended learning approaches to sustain instructional activities. Although this transition accelerated technology adoption worldwide, it also exposed significant inequalities in digital infrastructure, particularly within developing countries. In Nigeria, the pandemic revealed longstanding challenges including inadequate technological facilities, insufficient digital learning resources, poor internet connectivity, overcrowded classrooms, and limited opportunities for practical learning. These challenges remain particularly evident in Computer Studies, a subject that depends heavily on hands-on activities and continuous interaction with digital technologies.

Computer Studies occupies a strategic position within the Nigerian secondary school curriculum because it develops learners' digital literacy, computational thinking, problem-solving abilities, and fundamental programming skills. These competencies have become indispensable for higher education, employment, entrepreneurship, and national technological development. However, despite the importance of Computer Studies, instructional practices in many Nigerian secondary schools continue to rely heavily on theoretical classroom teaching with limited practical exposure. In many schools, large student populations share very few functional computers, making effective practical instruction extremely difficult. Consequently, students often develop low motivation, poor learning engagement, and inadequate practical competence.

Learning engagement has consistently been identified as one of the strongest predictors of academic achievement. It encompasses behavioural participation, cognitive investment, and emotional commitment during the learning process. Students who actively participate in learning activities, invest mental effort in solving problems, and develop positive attitudes toward learning generally demonstrate superior academic performance compared with learners who remain passive. Within Computer Studies education, maintaining high levels of engagement is particularly important because mastery requires repeated practice, experimentation, and interaction with digital tools.

Digital support systems have emerged as promising educational technologies capable of improving learner engagement. These systems extend beyond conventional e-learning platforms by integrating interactive multimedia content, personalized learning pathways, automated feedback mechanisms, learning analytics, progress monitoring, collaborative learning features, and intelligent instructional support into a unified learning environment. Properly designed digital support systems enable students to learn independently while simultaneously providing teachers with valuable information about students' learning progress and instructional needs.

Although numerous digital learning applications exist, relatively few have been specifically designed to address the instructional challenges facing Computer Studies education in Nigerian secondary schools. Most available platforms were developed for general online learning environments and rarely consider contextual constraints such as inadequate computer laboratories, unreliable internet connectivity, overcrowded classrooms, and limited teacher support. Consequently, significant opportunities remain for designing educational

technologies that directly respond to these contextual realities.

From an information systems perspective, this challenge represents an ideal Design Science Research (DSR) problem. Design Science Research focuses on creating innovative artifacts that solve important organizational and societal problems through systematic design, development, and evaluation. Rather than merely explaining educational phenomena, DSR emphasizes the creation of practical solutions capable of improving real-world practice. The central artifact of this study is therefore a digital support system designed specifically to enhance learning engagement in Computer Studies within Nigerian secondary schools.

Following the Design Science Research methodology proposed by Hevner et al. (2004) and Peffers et al. (2007), this study identifies the instructional challenges affecting Computer Studies education, establishes the design objectives for a digital support system, develops an educational artifact that addresses these challenges, and proposes an evaluation strategy for assessing its educational effectiveness. The resulting artifact combines pedagogical principles with software engineering practices to produce a practical educational technology capable of supporting both teachers and students.

The study contributes to educational technology, information systems, and Computer Studies education in three significant ways. First, it introduces a context-sensitive digital support system specifically designed for Nigerian secondary schools rather than adapting existing generic learning platforms. Second, it demonstrates the application of Design Science Research methodology in addressing educational challenges through artifact development. Third, it provides a theoretical and practical foundation for future implementation and empirical evaluation of digital learning technologies aimed at improving learner engagement and digital literacy within resource-constrained educational environments.

2. Related Work

2.1 Digital Technologies and Learning Engagement

Digital technologies have become an integral component of modern education because they provide learners with opportunities to interact with instructional content beyond the traditional classroom. Unlike conventional teacher-centred instruction, digital learning environments encourage active participation through multimedia resources, interactive exercises, virtual simulations, immediate feedback, and collaborative learning activities. Numerous studies have demonstrated that such environments improve students' motivation, participation, conceptual understanding, and academic achievement.

Learning engagement refers to the extent to which learners actively participate in educational activities and invest behavioural, cognitive, and emotional effort in the learning process. Fredricks et al. (2004) conceptualized learning engagement as comprising three interrelated dimensions: behavioural engagement, cognitive engagement, and emotional engagement. Behavioural engagement involves participation in learning activities and persistence in academic tasks. Cognitive engagement reflects the mental effort learners devote to understanding concepts and solving problems, while emotional engagement describes students' interest, enjoyment, confidence, and sense of belonging during learning. Educational researchers have consistently identified these three dimensions as strong predictors of academic success and long-term learning outcomes.

Digital learning systems contribute significantly to these dimensions by allowing learners to study at their own pace, receive immediate feedback, revisit difficult concepts, and monitor their learning progress. Bond et al. (2021), in a systematic review of online learning, reported that interactive digital environments substantially improve learner engagement when instructional content is carefully designed to promote collaboration, feedback, and learner autonomy. Similarly, Persico et al. (2021) found that digital learning platforms positively influence students' participation, motivation, and

course completion rates through structured interaction and personalized learning experiences.

Furthermore, multimedia learning environments have demonstrated considerable advantages over traditional instructional approaches. Mayer (2019) argued that combining visual and auditory instructional materials enables learners to process information more effectively than text-only instruction. Interactive multimedia therefore plays a significant role in improving students' understanding of complex concepts, particularly within science and technology-related disciplines.

2.2 Digital Learning in Computer Studies Education

Computer Studies is fundamentally practical in nature and requires students to develop knowledge through continuous interaction with computer systems and software applications. Consequently, effective instruction depends not only on theoretical explanation but also on practical demonstrations, experimentation, and guided practice.

Despite the importance of Computer Studies within Nigeria's secondary school curriculum, instructional delivery continues to face numerous challenges. Earlier work by Jegede and Owolabi (2003) identified inadequate computer laboratories, poor instructional facilities, insufficient hardware, and limited practical opportunities as major barriers affecting Computer Studies education in Nigerian secondary schools. Although technological development has progressed considerably since that study, many of these challenges remain evident today.

Recent studies similarly indicate that overcrowded classrooms, inadequate digital infrastructure, and insufficient instructional resources continue to reduce the effectiveness of Computer Studies instruction. Madawaki and Naabu (2022) observed that large class sizes significantly reduce teachers' ability to provide individualized support and monitor students' learning progress. These conditions negatively affect learners' motivation and engagement, particularly in technology-based subjects requiring practical interaction.

Teacher-related challenges also influence technology integration within Nigerian schools. Ifinedo et al. (2020) reported that teachers' technological competence, pedagogical beliefs, and institutional support significantly determine successful classroom technology integration. Even where digital facilities exist, inadequate teacher preparedness often limits their educational impact.

2.3 Educational Support Systems

Educational support systems are designed to complement classroom instruction by providing learners with continuous academic assistance throughout the learning process. Unlike conventional Learning Management Systems that primarily deliver learning materials, digital support systems integrate instructional content, communication tools, assessment mechanisms, personalized feedback, learning analytics, and progress monitoring into a unified educational environment.

Modern educational support systems increasingly incorporate adaptive learning technologies, gamification, intelligent tutoring mechanisms, and learning analytics to improve learner motivation and personalize instruction. Personalized learning environments have been shown to increase students' intrinsic motivation by allowing learners to control their learning pace and receive individualized instructional support (Alamri et al., 2020).

Similarly, gamification has emerged as an effective strategy for increasing learner participation through the integration of points, badges, leaderboards, challenges, and achievement systems. Li et al. (2024) concluded through a meta-analysis that gamification produces significant improvements in learner motivation, autonomy, and engagement when integrated appropriately into instructional design.

Progress monitoring also represents an essential component of educational support systems. Learning analytics enable both teachers and students to monitor academic progress continuously, identify

learning difficulties, and implement timely interventions. Such capabilities are particularly valuable within overcrowded classrooms where continuous individual monitoring is practically impossible.

2.4 Design Science Research in Educational Technology

Design Science Research (DSR) has become an established research paradigm within Information Systems for developing innovative artifacts that solve practical organizational and societal problems. Unlike behavioural research, which seeks to explain existing phenomena, DSR focuses on creating and evaluating artifacts capable of improving real-world practice.

Hevner et al. (2004) define Design Science Research as the systematic design, construction, demonstration, and evaluation of innovative artifacts intended to solve identified problems. Artifacts may include software applications, frameworks, methods, models, architectures, or processes. The success of Design Science Research is measured not only by theoretical contribution but also by the practical usefulness of the developed artifact.

Peffers et al. (2007) proposed a structured Design Science Research Methodology consisting of six iterative activities: problem identification, definition of solution objectives, design and development, demonstration, evaluation, and communication. This methodology has been widely adopted in educational technology research because it provides a systematic framework for developing educational software while maintaining scientific rigor.

Within educational technology, Design Science Research has been successfully applied to the development of intelligent tutoring systems, adaptive learning environments, recommender systems, learning analytics platforms, mobile learning applications, and collaborative learning environments. These studies demonstrate that DSR provides an appropriate methodological foundation for developing educational technologies that directly address instructional challenges.

3. Research Methodology

3.1 Research Paradigm

This study adopts the **Design Science Research (DSR)** paradigm to develop a digital support system that enhances learning engagement in Computer Studies among Nigerian secondary school students. Design Science Research is an established research methodology within the Information Systems discipline that emphasizes the creation of innovative technological artifacts to address real-world problems while simultaneously contributing to scientific knowledge (Hevner *et al.*, 2004).

Unlike behavioural research, which primarily explains or predicts existing phenomena, Design Science Research focuses on designing and developing artifacts that improve current practices. Such artifacts may include software systems, models, methods, frameworks, architectures, or processes. The central artifact developed in this study is a web-based digital support system designed to improve students' behavioural, cognitive, and emotional engagement in Computer Studies through interactive learning, personalized feedback, virtual practical activities, and continuous progress monitoring.

The selection of Design Science Research is appropriate because the objective of this study is not merely to investigate factors affecting learning engagement but to develop a practical technological solution capable of addressing identified instructional challenges within Nigerian secondary schools.

3.2 Design Science Research Methodology

The study follows the Design Science Research Methodology (DSRM) proposed by Peffers *et al.* (2007). The methodology consists of six iterative activities that guide the systematic development and evaluation of technological artifacts.

3.2.1 Problem Identification and Motivation

The first stage involves identifying the educational problem requiring technological intervention. Previous studies have shown that Computer Studies instruction in many Nigerian secondary schools is constrained by inadequate computer laboratories, overcrowded classrooms, insufficient instructional resources, limited practical learning opportunities, and weak learner engagement.

These challenges reduce students' opportunities to acquire practical digital skills and negatively affect their motivation, participation, and academic achievement. Since Computer Studies is fundamentally practice-oriented, there is an urgent need for a digital learning environment capable of supplementing classroom instruction and supporting independent learning beyond school hours.

The motivation for this research therefore arises from the need to design a context-sensitive educational technology that addresses these instructional deficiencies while supporting Nigeria's digital literacy agenda.

3.2.2 Definition of the Objectives for a Solution

Following problem identification, Design Science Research requires clearly defining the objectives that the proposed artifact should achieve.

The proposed digital support system was designed to achieve the following objectives:

i. provide interactive multimedia learning resources that improve conceptual understanding;

ii. increase behavioural, cognitive, and emotional engagement during Computer Studies instruction;

iii. support individualized and self-paced learning;

iv. provide virtual practical demonstrations where physical laboratory facilities are inadequate;

v. automate assessment and immediate feedback;

vi. monitor students' learning progress continuously;

vii. facilitate communication between teachers and students; and

viii. Support instructional decision-making through learning analytics.

These objectives were derived from the educational challenges identified in previous literature and the pedagogical requirements of Computer Studies education.

3.2.3 Design and Development of the Artifact

The third stage involves designing and developing the proposed artifact.

The artifact developed in this study is a web-based Digital Support System (DSS) consisting of five integrated instructional modules:

1. Interactive Learning Module
2. Virtual Demonstration Module
3. Assessment and Quiz Module
4. Learning Progress Monitoring Module
5. Feedback and Communication Module

The artifact was designed using modern software engineering principles and follows a client-server architecture that enables access through standard web browsers on desktop computers, tablets, and smartphones.

The front-end interface is developed using HTML5, Cascading Style Sheets (CSS3), and JavaScript to provide a responsive and interactive user experience. The server-side application manages authentication, learning resources, assessment records, communication services, and learner analytics using PHP or Python together with a relational database management system such as MySQL.

The architecture emphasizes simplicity, accessibility, scalability, and compatibility with the technological realities of Nigerian secondary schools.

3.3 Design Principles

The design of the proposed digital support system is guided by four complementary educational theories that collectively inform the instructional architecture of the artifact.

3.3.1 Constructivist Learning Theory

Constructivist Learning Theory emphasizes active knowledge construction through exploration, practice, and interaction. Consequently, the proposed system incorporates interactive tutorials, guided practical exercises, simulations, and problem-solving activities that encourage students to construct knowledge independently rather than passively receiving information.

3.3.2 Self-Determination Theory

Self-Determination Theory suggests that intrinsic motivation develops when learners experience autonomy, competence, and relatedness.

Accordingly, the artifact allows learners to progress at their own pace, provides immediate feedback that strengthens competence, and supports communication with teachers and peers to promote social interaction throughout the learning process.

3.3.3 Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning argues that meaningful learning occurs when instructional information is presented through coordinated visual and verbal representations.

The system therefore integrates animations, diagrams, videos, simulations, narrated demonstrations, and interactive illustrations to simplify complex Computer Studies concepts and reduce cognitive overload.

3.3.4 Activity Theory

Activity Theory views learning as a socially mediated activity involving interactions among learners, instructional tools, teachers, and educational objectives.

The proposed system therefore functions as an instructional mediator that connects students, teachers, learning resources, assessment activities, and communication services within a unified digital learning environment.

3.4 Demonstration Strategy

Within Design Science Research, demonstration refers to showing that the developed artifact can solve the identified problem.

The proposed digital support system is intended to be demonstrated within selected Nigerian secondary schools offering Computer Studies. Teachers will upload instructional materials and practical activities to the platform, while students will access learning modules, complete interactive exercises, participate in virtual demonstrations, attempt quizzes, monitor their learning progress, and communicate with teachers through the integrated messaging system.

The demonstration will illustrate how the artifact supports classroom instruction while extending learning opportunities beyond conventional classroom boundaries.

3.5 Proposed Evaluation Strategy

Evaluation is an essential component of Design Science Research because it determines whether the developed artifact satisfies its intended objectives. The effectiveness of the proposed system will be evaluated using both quantitative and qualitative approaches.

Quantitative evaluation will examine students' behavioural, cognitive, and emotional engagement using validated learning engagement instruments administered after interaction with the system. Additional measures such as assessment scores, system usage statistics, task completion rates, and learning progress indicators will provide objective evidence of system performance.

Qualitative evaluation will be conducted through usability questionnaires, interviews, and participant

feedback to assess users' perceptions regarding ease of use, usefulness, interface design, accessibility, and overall learning experience. The combination of these evaluation approaches will provide comprehensive evidence regarding the educational effectiveness, usability, and practical value of the proposed artifact.

4. Artifact Design and System Architecture

4.1 Overview of the Proposed Artifact

The principal artifact developed in this study is a **Digital Support System (DSS)** designed to improve learning engagement in Computer Studies among Nigerian secondary school students. The artifact was developed following the Design Science Research paradigm, where the creation of an innovative technological solution constitutes the primary scientific contribution. The system addresses instructional challenges identified in Nigerian secondary schools, including inadequate practical learning opportunities, overcrowded classrooms, and limited access to computers, insufficient instructional support, and low student engagement.

Unlike conventional Learning Management Systems (LMS), which primarily focus on content distribution and administrative tasks, the proposed Digital Support System integrates instructional support, practical simulations, learner analytics, assessment, communication, and personalized learning into a unified educational platform. The system functions as an instructional companion that supports students throughout the learning process while providing teachers with tools for monitoring learner progress and delivering timely interventions.

The architecture of the proposed system emphasizes accessibility, usability, scalability, and affordability. Since many Nigerian secondary schools operate under infrastructural constraints, the artifact was intentionally designed as a lightweight web-based platform requiring minimal computing resources and capable of operating on shared desktop computers, tablets, laptops, and smartphones.

4.2 Design Objectives of the Artifact

The design of the Digital Support System was guided by seven major objectives:

1. Improve students' behavioural, cognitive, and emotional engagement in Computer Studies.
2. Support self-paced and personalized learning.
3. Increase opportunities for practical learning through virtual demonstrations.
4. Provide immediate formative assessment and automated feedback.
5. Enable continuous monitoring of learner progress.
6. Improve communication between teachers and students.
7. Support effective classroom management through learning analytics.

These objectives informed every design decision made during artifact development and ensured alignment between educational theory and software functionality.

4.3 Functional Requirements

The proposed Digital Support System satisfies several functional requirements necessary for effective instructional support.

Student Functions

The system enables students to:

i. register and securely access their learning accounts;
ii. view Computer Studies learning materials;
iii. watch instructional videos and animations;
iv. participate in interactive practical simulations;
v. complete quizzes and assignments;
vi. receive immediate automated feedback;
vii. monitor individual learning progress;

viii. communicate with teachers;
ix. participate in discussion forums; and
x. Earn badges and achievement points through gamified activities.

Teacher Functions

The system enables teachers to:

i. create learning modules;
ii. upload instructional materials;
iii. manage classes;
iv. assign assessments;
v. monitor students' learning progress;
vi. identify struggling learners;
vii. respond to students' questions;
viii. review learning analytics; and
ix. Generate performance reports.

Administrator Functions

System administrators are responsible for:

i. user management;
ii. role assignment;
iii. database maintenance;
iv. system security;
v. content moderation;
vi. backup management;
vii. system configuration; and
viii. overall platform administration.

4.4 Non-Functional Requirements

In addition to functional capabilities, the Digital Support System satisfies important non-functional requirements.

Usability: The interface should be intuitive and easy to navigate for both teachers and students regardless of their level of digital literacy.

Reliability: The system should maintain stable performance during simultaneous access by multiple users while minimizing system downtime.

Scalability: The architecture should support future expansion to accommodate additional schools, users, and learning modules without major structural modifications.

Security: User authentication, encrypted passwords, secure communication protocols, and controlled access permissions should protect learner information and institutional data.

Portability: The platform should operate across different operating systems and web browsers without requiring software installation.

Performance: Learning materials should load efficiently even under limited internet bandwidth to accommodate schools located in rural communities.

4.5 System Architecture

The proposed Digital Support System adopts a three-tier client-server architecture consisting of the Presentation Layer, Application Layer, and Data Layer.

Presentation Layer

The presentation layer provides the graphical user interface through which teachers and students interact with the system. It is developed using HTML5, CSS3, Bootstrap, and JavaScript to ensure responsiveness across multiple devices.

Major interface components include:

i. Login Page
ii. Student Dashboard
iii. Teacher Dashboard
iv. Learning Module Interface
v. Quiz Interface
vi. Progress Dashboard

vii. Communication Portal

Application Layer

The application layer implements the system's business logic.

Its major responsibilities include:

i. user authentication;
ii. course management;
iii. assessment processing;
iv. progress analytics;
v. communication services;
vi. recommendation engine;
vii. notification management; and
viii. Gamification services.

The application layer may be implemented using PHP Laravel or Python Django depending on deployment requirements.

Data Layer

The data layer stores all persistent system information.

Major database entities include:

i. Students
ii. Teachers
iii. Courses
iv. Learning Modules
v. Assessments
vi. Quiz Results
vii. Progress Records
viii. Messages
ix. Notifications
x. Achievement Badges

A relational database such as MySQL provides efficient storage, retrieval, and management of these records.

4.6 Core Modules of the Artifact

The Digital Support System consists of five integrated instructional modules.

Module 1: Interactive Learning Module

This module delivers curriculum content through multimedia resources including text, animations, instructional videos, diagrams, simulations, and interactive exercises.

Students' progress through structured learning units while controlling their own pace of learning.

Major features include:

i. multimedia lessons;
ii. interactive diagrams;
iii. embedded videos;
iv. programming examples;
v. downloadable learning materials; and
vi. Self-paced navigation.

This module primarily supports cognitive engagement.

Module 2: Virtual Demonstration Module

This module compensates for inadequate practical laboratory facilities by providing simulated practical exercises.

Students can virtually perform tasks such as:

i. computer hardware identification;
ii. operating system navigation;
iii. file management;
iv. Microsoft Office applications;
v. internet operations;
vi. programming practice; and
vii. Database manipulation.

Interactive demonstrations provide guided learning experiences that closely resemble real laboratory practice.

Module 3: Assessment and Feedback Module

The assessment module evaluates learner understanding using:

i. multiple-choice questions;
ii. true-or-false questions;
iii. drag-and-drop exercises;
iv. practical simulations;
v. coding exercises; and
vi. Scenario-based assessments.

Immediately after submission, the system provides:

i. automated grading;
ii. explanations for incorrect answers;
iii. recommended learning resources; and
iv. Personalized revision suggestions.

Immediate feedback promotes continuous learning improvement and strengthens learner confidence.

Module 4: Learning Analytics and Progress Monitoring Module

This module continuously records learner activities and transforms them into meaningful analytics.

Progress indicators include:

i. lesson completion rate;
ii. assessment performance;
iii. learning time;
iv. participation frequency;
v. practical activities completed;
vi. badge achievements; and
vii. Mastery level.

Teachers can identify students requiring additional academic support through visual dashboards.

Module 5: Communication and Collaboration Module

Effective learning requires continuous interaction among participants.

This module supports communication through:

i. teacher-student messaging;
ii. discussion forums;
iii. announcement boards;
iv. assignment notifications;
v. peer collaboration; and
vi. Academic support discussions.

These collaborative features strengthen emotional engagement and encourage knowledge sharing among learners.

4.7 User Interaction Workflow

The operational workflow of the Digital Support System follows six major stages:

Stage 1: User Authentication

Students and teachers securely log into the system.

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Stage 2: Dashboard Access

User's access personalized dashboards displaying learning activities and progress.

↓

Stage 3: Learning Activities

Students study multimedia lessons and complete practical demonstrations.

↓

Stage 4: Assessment

Students complete quizzes and practical exercises.

↓

Stage 5: Automated Feedback

The system instantly grades assessments, provides explanations, and updates learner records.

↓

Stage 6: Learning Analytics

Teachers monitor learner progress and implement targeted instructional interventions where necessary.

This workflow establishes a continuous learning cycle that promotes active participation, timely feedback, and sustained learner engagement.

4.8 Artifact Novelty

The proposed Digital Support System introduces several innovations that distinguish it from existing educational technologies.

First, it is specifically designed for the Nigerian secondary school Computer Studies curriculum rather than serving as a generic learning platform.

Second, it integrates instructional delivery, practical simulation, learner analytics, assessment, communication, and gamification within a single unified system.

Third, the artifact explicitly incorporates behavioural, cognitive, and emotional engagement as primary design objectives.

Fourth, the architecture accommodates infrastructural limitations commonly experienced in developing countries by emphasizing lightweight deployment, browser accessibility, and minimal hardware requirements.

Finally, the artifact is grounded in the Design Science Research paradigm, ensuring that every component is theoretically justified and directly linked to solving an identified educational problem rather than simply incorporating technology for its own sake.

5. System Design Models

5.1 Overview

A fundamental characteristic of Design Science Research is the rigorous specification of the proposed artifact before implementation. System design models provide a structured representation of the architecture, functionality, behaviour, and data organization of the Digital Support System (DSS). They facilitate communication among researchers, software developers, educators, and other stakeholders while ensuring that the artifact satisfies its intended educational objectives.

The proposed Digital Support System is modelled using the Unified Modeling Language (UML), which is widely adopted in software engineering for visualizing and documenting system designs. The principal models include the Use Case Diagram, Activity Diagram, Sequence Diagram, Component Diagram, Deployment Diagram, and Entity-Relationship Diagram. Together, these models describe the interaction between users and the system, the sequence of system operations, software components, deployment environment, and database structure.

5.2 Use Case Model

The Use Case Model illustrates the interactions between users and the Digital Support System. Three categories of users interact with the platform: students, teachers, and system administrators. Each user performs specific functions according to assigned access privileges.

Students use the system to authenticate their accounts, access learning resources, participate in virtual practical activities, complete assessments, monitor learning progress, communicate with teachers, and receive personalized feedback.

Teachers upload instructional materials, create assessments, monitor learners' progress, respond to students' questions, and generate academic reports that support instructional decision-making.

System administrators oversee user registration, assign user roles, maintain databases, configure system settings, and ensure the security and availability of the platform.

The Use Case Diagram therefore demonstrates how the Digital Support System supports all major instructional activities within Computer Studies

education while maintaining role-based access control.

5.3 Activity Model

The Activity Diagram represents the workflow followed during students' interaction with the system. The workflow begins when a user logs into the platform using valid authentication credentials. Upon successful authentication, the user is directed to a personalized dashboard displaying available learning activities.

Students then select a learning module and study multimedia instructional resources. After completing a lesson, they proceed to practical demonstrations and interactive exercises that reinforce conceptual understanding. The system subsequently presents formative assessments designed to evaluate students' mastery of the instructional content.

Following assessment submission, the system automatically grades responses, generates individualized feedback, updates learner progress records, and recommends additional learning resources where necessary. Teachers simultaneously receive updated learning analytics that assist them in identifying students requiring academic intervention.

The workflow concludes when the learner logs out of the platform, while all academic activities remain securely stored for future access and analysis.

5.4 Sequence Model

The Sequence Diagram describes the chronological exchange of information among the user interface, application server, database server, and notification services during a typical learning session.

Initially, the student submits login credentials through the graphical interface. The authentication module validates these credentials against records stored within the database. Upon successful verification, the server retrieves the learner's dashboard information and transmits it to the client application.

When the learner selects a lesson, the application retrieves the requested instructional content from the database and displays it through the user interface. Upon completion of learning activities, assessment responses are transmitted back to the application server for automatic marking.

Assessment results are stored in the database, learner progress records are updated, and personalized feedback is generated. Simultaneously, notification services inform teachers of completed activities and update learning analytics dashboards. This interaction sequence ensures that learner records remain synchronized throughout the instructional process.

5.5 Component Model

The Component Diagram illustrates the major software components that collectively constitute the Digital Support System. Each component performs specialized functions while interacting with other components through clearly defined interfaces.

The User Interface Component provides graphical interaction between users and the system. It supports responsive web pages, dashboards, multimedia presentation, assessment interfaces, and communication tools.

The Authentication Component manages user registration, login, session management, password encryption, and role-based authorization.

The Learning Management Component administers instructional resources, curriculum organization, multimedia content, and virtual practical activities.

The Assessment Component generates quizzes, grades learner responses automatically, calculates performance indicators, and provides immediate feedback.

The Analytics Component processes learner interaction data, produces progress reports, visualizes performance trends, and supports instructional decision-making.

The Communication Component manages announcements, messaging services, discussion forums, notifications, and collaborative learning activities.

The Database Component stores all persistent system

information, including user accounts, learning materials, assessment records, communication logs, and learner analytics.

Together, these components provide a modular architecture that facilitates future maintenance, scalability, and extension of system functionality.

5.6 Deployment Model

The Deployment Diagram illustrates the physical configuration of the Digital Support System. The architecture follows a client-server model consisting of three major deployment environments.

The client environment includes desktop computers, laptops, tablets, and smartphones used by teachers and students to access the platform through standard web browsers.

The application server hosts the business logic, authentication services, instructional modules, assessment engine, analytics services, and communication infrastructure.

The database server stores learner information, instructional resources, assessment records, user profiles, progress reports, and system configuration files.

Communication between clients and servers occurs through secure internet or institutional network connections using encrypted communication protocols. This deployment configuration enables the platform to operate effectively within school computer laboratories as well as through remote internet access.

5.7 Entity-Relationship Model

The Entity-Relationship (ER) Model describes the logical organization of the system database.

The principal entities include:

i. Student
ii. Teacher
iii. Administrator
iv. Course
v. Learning Module
vi. Lesson
vii. Assessment
viii. Question
ix. Student Response
x. Result
xi. Progress Record
xii. Discussion Forum
xiii. Message
xiv. Notification
xv. Badge
xvi. Achievement

A student may enrol in multiple courses, while each course contains several learning modules. Each learning module consists of multiple lessons and assessments. Assessments contain several questions, and students submit responses that are automatically evaluated to produce assessment results.

Progress records summarize learner performance across completed activities and generate learning analytics used by teachers to monitor student engagement. Communication entities such as messages and discussion forums support interaction between teachers and learners, while achievement records document gamification outcomes.

The relational database design minimizes redundancy, maintains referential integrity, and supports efficient retrieval of instructional and learner data.

5.8 Design Validation

The system design was validated conceptually by ensuring alignment between identified educational challenges, instructional theories, functional requirements, and software architecture. Each system component directly addresses one or more design objectives established during the Design Science Research process.

The Interactive Learning Module addresses cognitive engagement through multimedia

instruction and self-paced learning. The Virtual Demonstration Module compensates for limited laboratory facilities by providing simulated practical experiences. The Assessment Module promotes continuous learning through immediate feedback, while the Analytics Module supports evidence-based instructional decisions by tracking learner progress. The Communication Module strengthens behavioural and emotional engagement by facilitating interaction between students and teachers.

This alignment demonstrates that the proposed artifact is not merely a technological solution but a pedagogically informed educational system whose design is grounded in established learning theories and Design Science Research principles.

6.6 Expected Outcomes

Based on the theoretical foundations and system design, the proposed Digital Support System is expected to produce several educational benefits. Students are expected to demonstrate higher levels of behavioural participation through increased interaction with learning resources and practical activities. The multimedia instructional approach and virtual demonstrations are expected to improve conceptual understanding and cognitive engagement by encouraging active learning and independent exploration. Immediate feedback and personalized learning recommendations are expected to enhance learner confidence, motivation, and emotional engagement. Teachers are expected to benefit from improved monitoring capabilities, enabling timely identification of struggling learners and evidence-based instructional decision-making.

Overall, the artifact is expected to contribute to improved academic achievement, enhanced digital literacy, and increased practical competence in Computer Studies.

7. Conclusion

This study presented the design of a Digital Support System (DSS) aimed at enhancing learning engagement in Computer Studies among Nigerian secondary school students using the Design Science Research (DSR) paradigm. The motivation for the study arose from persistent challenges affecting Computer Studies education in Nigeria, including inadequate instructional resources, overcrowded classrooms, limited access to functional computer laboratories, insufficient opportunities for practical learning, and low levels of student engagement. These challenges continue to hinder the development of digital literacy and practical computing skills that are essential for success in the twenty-first century.

Guided by the Design Science Research Methodology (DSRM), the study systematically identified the educational problem, established the objectives of a technological solution, designed an innovative educational artifact, and proposed an evaluation framework for assessing its effectiveness. The resulting Digital Support System integrates interactive multimedia instruction, virtual practical demonstrations, automated assessment, learning analytics, progress monitoring, and communication tools within a unified learning environment. The design of the artifact was informed by Constructivist Learning Theory, Self-Determination Theory, the Cognitive Theory of Multimedia Learning, and Activity Theory, thereby ensuring that technological features are aligned with established pedagogical principles.

The proposed artifact contributes to educational technology and information systems research by demonstrating how Design Science Research can be applied to develop context-sensitive educational solutions for resource-constrained learning environments. Unlike many existing digital learning platforms, the proposed system was specifically designed to address the instructional realities of Nigerian secondary schools and the practical requirements of Computer Studies education. By integrating learner-centred instructional strategies with software engineering principles, the artifact provides a scalable and adaptable framework capable of improving behavioural, cognitive, and emotional engagement among learners.

From a practical perspective, the Digital Support System offers teachers an effective platform for delivering instructional content, monitoring learner

progress, providing timely feedback, and supporting individualized learning. Students, on the other hand, benefit from interactive learning experiences, self-paced study, virtual practical activities, and continuous formative assessment, all of which contribute to improved motivation and academic performance. The modular architecture of the system also allows future enhancement through the integration of emerging technologies such as artificial intelligence, adaptive learning, predictive learning analytics, and intelligent tutoring systems.

Although the study proposes a comprehensive educational artifact, empirical validation remains necessary to establish its effectiveness under real classroom conditions. Future research should therefore implement the system within secondary schools, evaluate its usability and educational impact using mixed research methods, and compare its performance with existing instructional approaches. Additional studies may also investigate the integration of mobile learning, gamification, artificial intelligence, and learning analytics to further improve learner engagement and educational outcomes.

In conclusion, this study demonstrates that Design Science Research provides a rigorous and effective methodological framework for addressing educational challenges through innovative technological design. The proposed Digital Support System represents a practical contribution toward improving Computer Studies education and advancing digital literacy in Nigerian secondary schools. It is expected that the findings and artifact presented in this study will serve as a valuable reference for researchers, educators, software developers, and policymakers seeking sustainable technology-based solutions for improving teaching and learning in developing countries.

References

Alamri, A., Watson, S., & Watson, W. (2020). Learning technology models that support personalization within online learning environments: A systematic review. *Education and Information Technologies, 25*(5), 4075–4098.

Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2021). Emergency remote teaching in higher education: Mapping the first global online semester. *International Journal of Educational Technology in Higher Education, 18*(1), 50.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109.

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly, 37*(2), 337–355.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75–105.

Ifinedo, E., Rikala, J., & Hämäläinen, T. (2020). Factors affecting Nigerian teachers' use of information and communication technology. *Education and Information Technologies, 25*(2), 1327–1347.

Li, M., Hu, X., & Chen, Y. (2024). Gamification in education: A meta-analysis of its effects on student engagement and academic achievement. *Computers & Education, 208*, 104980.

Madawaki, M. A., & Naabu, A. (2022). Classroom management practices and students' academic engagement in Nigerian secondary schools. *Journal of Education and Learning, 11*(4), 78–90.

Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems, 24*(3), 45–77.

Persico, D., Manca, S., & Pozzi, F. (2021). Adapting the technology acceptance model to evaluate online learning environments and student engagement. *Educational Technology Research and Development, 69*(4), 2019–2040.

Ryan, R. M., & Deci, E. L. (2020). *Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions*. Contemporary Educational Psychology, 61, 101860.

UNESCO. (2023). *Global Education Monitoring Report 2023: Technology in education—A tool on whose terms?* UNESCO Publishing.

United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. United Nations.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425–478.

World Bank. (2023). *The State of Global Learning Poverty: 2023 Update*. World Bank.