Original Research Article

Digital Laboratory Framework (DLF); A tool for Effective Practical Delivery in Federal Polytechnic Offa, Nigeria

Abstract

The research provides vital insights into technical and engineering education and practice as a key to effective teaching of practical for Computer Engineering Students in an efficient and applied manner which is an indispensable factor. Since the introduction of Computer Engineering in 1997 at Federal Polytechnic Offa, applying the theories has allowed the students to develop their commercial literacy and ambition in the Polytechnics. Using laboratories for routine practical has been traditional, and the technology trend has gone beyond conventional methods. Digital Laboratory Framework (DLF) is a tool for technical education, where practical teaching will take the form of virtual learning. The team intends to develop a digital laboratory to complement the traditional method for National Diploma (ND) and Higher National Diploma (HND) in Computer Engineering to cover core digital and analogue electronics pre-requisite courses. The teaching and practice of Engineering serve as the essential entrepreneurship skills with a keynote to address the fundamental requirements needed to establish a successful career using student cognitive learning, student performance and evaluation concerning technical skills acquisition. The result prepares undergraduates ahead for industrial skills. It enables them to specialize in any computer engineering options and help produce competent Nigerian graduates as engineers with a total capacity to develop the nation through innovative technologies.

Key words: Digital, laboratory, practical, National Diploma, Computer engineering, Higher National Diploma

1.0 Introduction

The laboratory teaching method in Engineering has become a vital tool among Technologists and Instructors. With the strategic plan employed, they extolled the significant usage of the laboratory. The issue of the virtual laboratory has taken over the use of traditional methods in conducting practicals in most developed countries. As a result of virtual laboratories, the tertiary institute of technology emerged the best in its adoption to reinforce the teaching and practice of engineering [1].

Technologists and Instructors of Computer Engineering Technology, Federal Polytechnic Offa require more conveniences to make experimental work the centre of their instruction. The issue of consumables (materials) has become a common problem in conducting effective practical (laboratory work and practical exams) and in the case of defective equipment to carry out practical work[2]. The accessibility to consumables and limited equipment is another predominant problem that makes practical teaching surfer.

The research will bring synergy to engineering innovation through self-development, practical teaching and practice that would benefit technical staff and undergraduate students at all levels. The Nigerian economic situation demands transformation through engineering innovation to improve engineering practice and prepare undergraduate students for industrial attachment and entrepreneurial skills[3].

The research will also sensitize technical staff on the need to look for alternatives to the traditional laboratory method of teaching engineering courses by linking the trend and evolution of the use of laboratory work in engineering to the latest scientific' use of the experimental approach. Equally, it demands answers to why technical staff thinks the laboratory method should take centre stage in engineering practice and as the core backbone in engineering courses. We intend to provide evidence to illustrate what we consider a tool for engineering practice as far as experiment and laboratory work are concerned. We, therefore, affirmed that virtual laboratories would bring synergy for effective teaching and learning [4].

Real-time laboratory practice has become a significant challenge since the beginning of global pandemics such as COVID -19 where limited time is scheduled for practical teaching and training in Nigeria[5]. The concept of social distancing has created a wide gap between laboratory instructors/technologists and the students, affecting practical teaching qualities in the laboratories, especially in Federal Polytechnic Offa, Nigeria. Using "Digital Laboratory

Framework" (DLF) will compensate for time management in teaching, add value to adequate education, and improve students' learning centres.

This is to improvise real-time laboratory concepts to design and develop the "Digital Laboratory Framework" (DLF) for practical delivery in the department of Computer Engineering at Federal Polytechnic Offa, Nigeria. Create synergies improvement on students' cognitive learning and enable quick access to teaching resources from remote locations [6].

2.0 Literature Review

The department of Computer Engineering in Nigeria was the first to be established in Nigeria polytechnic in 1997. Meanwhile, the use of the laboratory method in Engineering originated from the ideas of early scientists [7]. In 2009, the management of Federal Polytechnic Offa recruited more technologists and instructors to aid the teaching of practical courses in Computer Engineering Technology (Computer Engineering; The Federal Polytechnic Offa, n.d). The newly employed technologists then work together as a team to develop practical manuals for all core courses taught at the Departmental level and brainstorm through self-development on local training and modality of practical teaching in the department using the available equipment [8].

The department is involved in practical examinations with the support of management by providing material required for teaching and practising experiment exercises which have transformed Computer Engineering through innovative technical experiments. We observed historically when [9] claimed that the idea of experimental science and scientific proof began to influence about 1590 " "when scientists started basing their work on deliberately contrived experiments. The technologists emerged and developed a series of practical monographs and published two textbooks with the combination of the National Diploma (ND) and Higher National Diploma (HND). Their projection is to enhance the practical contents together purposefully to ease the teaching of practical courses and serve as a guide to students on the modality of conducting experiments in the laboratory and writing report books.

Considering the importance of practical implementation in workshops and laboratories with the adequate equipment for teaching Engineering courses, the National Board for Technical Education (NBTE) suspended admission of students into all Engineering Programs at the Federal Polytechnic Idah, Kogi State, for lack of these facilities [10].

We observed that the teaching of theory with practical contributes to the success rate of undergraduate students in final year project implementation, therefore incorporating miniprojects along with weekly experiments as the idea of a virtual laboratory assist students in their various courses in developed countries.

These will rebuild students' cognitive centre of learning since Shulman and Tamir'sTamir's (1973) reviewed science and technology teaching research. They highlighted three rationales:

1. The concept inside the science and engineering curriculum is highly complex and abstract.
2. Students need to practice appreciating the spirit and methods of science and engineering.
3. Practical work is like a physical phenomenon and is intrinsically interesting to students.

A few objectivities in using the laboratory for routine practicals come with the composite objectives of using laboratory work in science teaching. Shared the same opinion of practical strength in research and development. The position of instructor and technologist, primarily known as educator according to [9,11], articulated research discovery in science and engineering. Project development is a key factor that defines the overall evaluation of student performance and determines their graduation from a higher institution. Spann et al. [12,13] highlighted the turnout for practical work as the framework of training students and the pathway for student future imposing.

Technological education has advanced in theory and practical teaching at higher institutions in developed nations like the USA, Canada, Germany, and China. Our research will emulate the framework in the advanced nations (copy technology) to reform practical modality in tertiary institutions in Nigeria. We will emphasize core laboratory work using demonstration and teaching concepts to strengthen the quality of laboratory experiments using laboratory equipment and virtual laboratory (Online Service initiative). [14 -17] emphasized and wrote up position statements to support the use of laboratory work at different levels of education.

3.0 Methodology and Design

In this section, the conceptual view of Digital Laboratory Framework" (DLF) and it all aspect is presented. This comprises of the basic requirement that DLF is expected to satisfied on the long run. A descriptive of basic composition of the DLF and the typical usage of case of how DLF can be use to effective virtual practical initiative.

3.1 Requirement of the Digital Laboratory Framework" (DLF)

The proposed Digital Laboratory Framework" (DLF) will be initiated by exploring NBTE curriculum for ND and HND core departmental courses in Computer Engineering Technology Federal Polytechnic Offa, by extracting practical contents and segment them in modules using experimental procedures.

3.1.1 Usability of Digital Laboratory Framework

Therefore, integrate digital laboratory is used to provides access to real devices and browsers though an automation interface with a guaranteed level of uptime, or service availability, to support Agile development of web and mobile apps[13,14,16]. Hence, the comparative analysis is run from the developed local contents "practical manual" of the NBTE curriculum to enable.

Digital Laboratory Framework form the integral part of cloud computing to actualize the proposed virtual laboratory concept. The algorithm of waterfall will be adopted in the earlier stage of the design to follow with the implementation, harmonious data will be used to present a concentric databank for virtual laboratory and transform the existing practical manuals from the department of Computer Engineering Technology within the global scope of digital and analogue electronics and integrate to cloud. This enable the digital laboratory framework with optimal control structure to register students and facilitators. Therefore, the research will apply structural programming language with the aid of deep learning algorithm to achieve electronics digital laboratory.

3.2 Support for Data Analytics

The features of the grading system of DTF are incorporated as added value educational training guidelines, as shown in figure 1, and this enables facilitators (Technologists and Instructors) to evaluate the performance of students in their practical courses. The profile verification system is to be developed using a matriculation algorithm for easy grading and documentation of student performance. The guide tools of DLF are a cross-cut between the education system as a study entity, target devices and back-end analytics and the efficient usage of the virtual laboratory is a composite function of the platform shown in figure 1, equipment and back-end analytics.

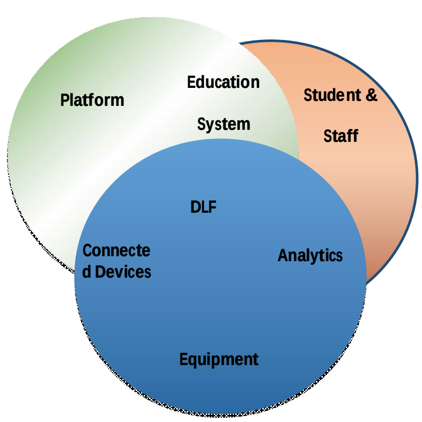

Figure 1: Composite function of DLF

A digital laboratory framework is designed to add intelligence to existing educational electronic data with ‘Data Analysis’ algorithms. The practical usage of DLF allows mobility for quick and easy access to instructional material and encourages self-practical practices in real-time. The internal mechanical of DLF could propagate simulation and prediction tools to reduce duplication and provide opportunities to integrate incongruent systems using a single platform/ single software, with capabilities of integrated experimental solutions through single-click access.

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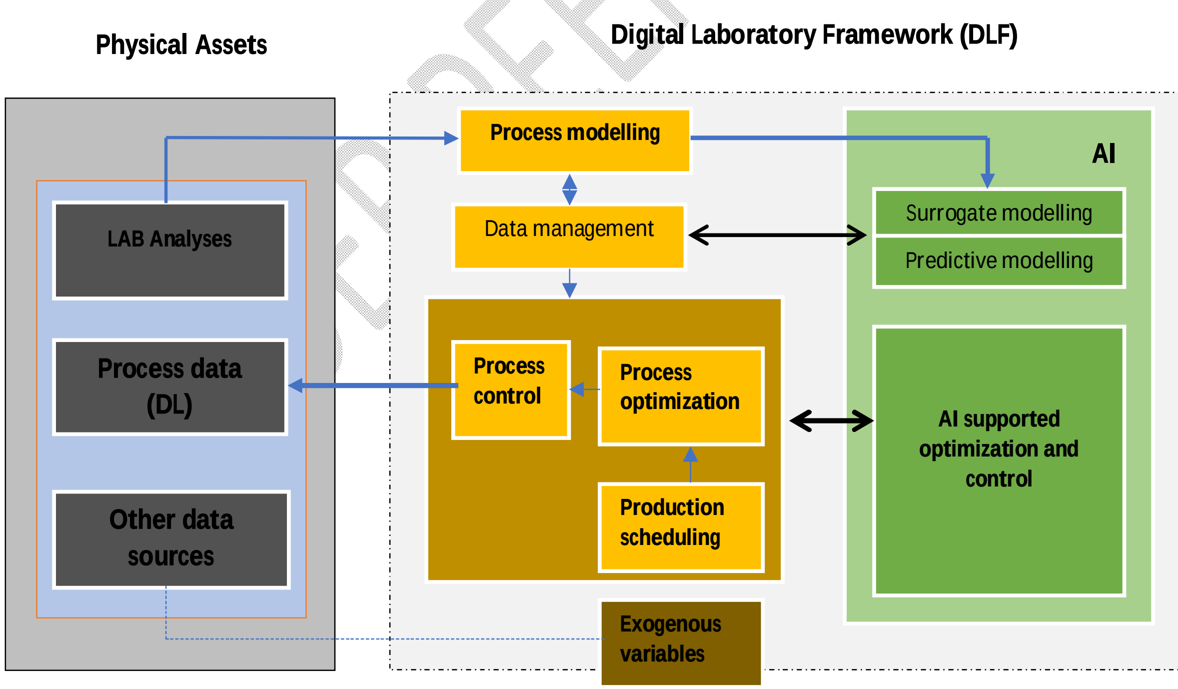

Figure 2: An overview of composition of the DLF for Experimental solutions using Data Analysis framework

3.3 Backend Data Analytic and Physical asset:

This is a suite of data analytics and information services that enable coordination of DLF to specific aspirations/ expectations from a digital laboratory (see figure 2):

- Produce new samples using experiment guilds "suggest" the new testing method most compatible with a component to achieve laboratory objectives.
- Allow the system to predict outcomes and take measurements based on historical data.
- DLF is designed based on learning engine performance that could suggest improvements based on experimental aims and objectives.

PDF Operational Efficiency help accelerate experimental work based on observation, and its efficiency could improve productivity and turnaround time, increasing customer satisfaction, as shown in figure 2.

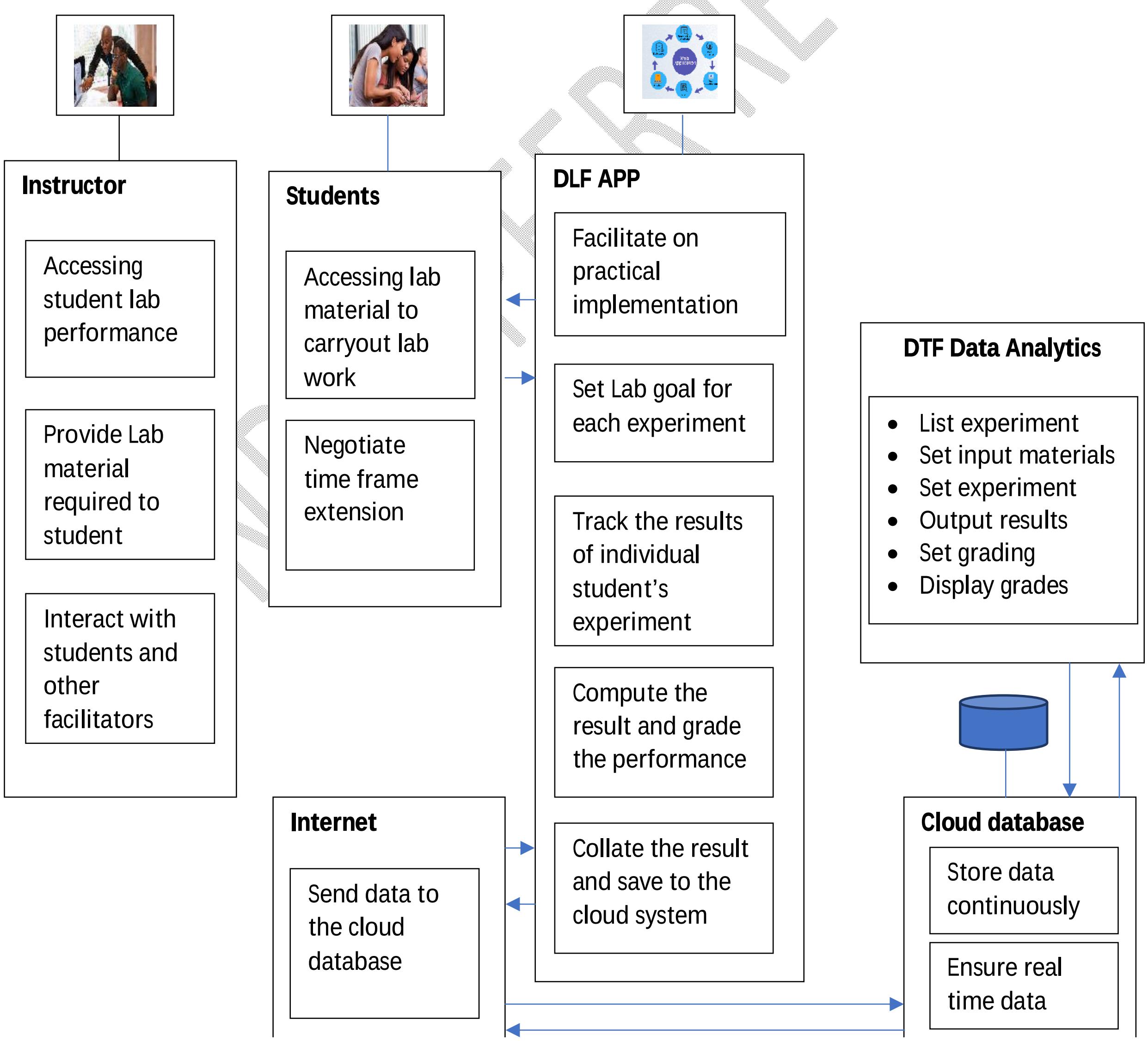

Figure 3: Overview features of Digital Laboratory Framework (DLF) for real-time practical framework

4.0 Discussion

DTF is an integral part of educational training tools shown in figure 3. This paper primarily centred on a generic framework for digital laboratory development in computer engineering, including other sisters in engineering from an operational perspective. The main building blocks of the functional digital laboratory shown in figure 3 above are presented: data management, process modelling, process optimization, process control, and deployment. Strong motive is centred on the advanced process control hierarchy. Additionally, the role of artificial intelligence in the development and deployment of operational digital laboratory in practical process initiation is presented, particularly regarding surrogate modelling, predictive modelling and AI-supported optimization and control. Consequently, the potential for new educational models induced by digitalization is illustrated in figure 4 and describes an outlook for the prospective research framework of this study.

4.1 Research Framework

"Digital Laboratory Framework" (DLF) is an innovative research project purposeful for practical teaching and practice concepts as an effective online tool for engineering education and practice. This research focuses on developing cross-platform using virtual laboratory and real-time experimental procedures to explore ideas in a well-developed practical implementation of electronics concepts.

The virtual laboratory concept derives from a cloud computing initiative program of studies from developed countries. In contrast, the real-time experiment is a new concept derived from the online learning concept, which will show the use of laboratory equipment in real time and will be conceptualized for DLF to carry out the practical vision in line with the NBTE curriculum. The existing manuals will be considered the research framework, and further modifications will be published as a review edition of the practical manual for ND and HND programs.

There are a few key things to be considered in the process of implementing an integrated solution DTF in educational practicals for laboratories:

- **DTF Integrated solutions are expensive:** The cost incurred is based on the number of applications per course covering whole academic programmes in the engineering field. The data types include instruments and equipment with the feature of API, integration, and several licensees required per API(s) used in the software development process.

- **DTF Varying implementation time:** The DTF Implementation time varies depending on the aim of the experiment (number of laboratories, equipment, Computer Graphics, Electronics, Applications and so on)
- **DTF Integration with instruments:** Hardware Integration depends on the number of instruments and API(s) needed and their compatibility with the integration solution (technological approach). Each laboratory in engineering has multiple instruments, standalone applications and systems.
- **DTF Method conversion/ coding**: In other to develop the full system and keep it running, **t**he process is time-consuming as the approach needs programming coding, wherein the user requirements are provided by practical courses matter experts to coders who don't understand the workflow of the methods in the experiment guide in the curriculum.
- **DTF Risk assessment:** There are different ways of accessing risk in software development. Multiple tools are required to assess risk, as complex integration DTF solutions have numerous applications and systems that vary in the NBTE curriculum, as mentioned in the introduction. It is essential to assure compliance and sustainability of the solution for each experiment in the case of some courses that are practically orientated and make it risk-proof.
- **Development Validation plan:** Typically, in the case of integrated electronic systems for DTF, this involves high-skill programming, hardware interfacing, as well as computer system validation, including various software applications to be developed in a modular form and cascade into a functional system that may require a detailed approach to deal with its complexity.
- **Dealing with the right technology:** The challenge is finding technology that can host all applications in developing a DTF solution. For instance, ERP systems are designed for standalone laboratory instruments and applications.
- **Training and recruitment of the user base:** An enterprise solution form of STF requires proper training & management of a large number of skilled users and system administrators to DTF solutions and can train and retrain undergraduates in the engineering field.

Case Use and User Training. All users (students, staff and technical personnel) in the proposed study must be trained to use a digital laboratory framework and computer system. This is particularly important because the subjects in the study would mostly be for educating students on the bases of laboratory training and the way to go about the empirical procedure. This makes it necessary to conduct orientation and training sessions for them. The training will include all technologists, instructors and lecturers in charge of practical courses and students enrolling to participate in the routine practice for this study.

5.0 Recommendation

DTF technical education and industry capabilities can create value across the five most common areas where lab metrics are measured: innovation, Data Quality, Data Security, Operational Efficiency, and Costs/Profitability.

Application of DTF can be connected to and integrated with other laboratory informatics systems, communication systems, laboratory information management systems (LIMS), analytical instrumentation, cybercrime, biomedical, chromatography data systems (CDS), scientific data management systems (SDMS), modelling and simulation programs, chemical inventory systems and scientific databases, and business-level systems such as document management systems, systems applications products and manufacturing execution systems. The initiation of a digital electronic lab environment provides several advantages to education and industries.

5.1 Conclusion

The study has presented a review of the literature on digital laboratory framework (DLF) for practically oriented courses as an alternative to face-to-face laboratory works. The study indicates that digital laboratory is being presently embraced worldwide more than face-to-face laboratory works for practical delivery in higher institutions. Several trial implementations of the framework could be used to derive the benefits from this research output. It is necessary to key in on DLF, especially in developing countries like Nigeria.

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