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Research Article

Exploring the Instructional Benefits and Challenges of Hypermedia Instructional Resources in Enhancing Teaching and Learning Outcomes in Electrical/Electronics Technology Education in Northern Nigerian Universities

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Abstract— This study employs a sequential mixed-methods design to investigate the instructional benefits and challenges of using hypermedia instructional resources in Electrical/Electronic Technology (EET) education at northern Nigerian universities. The research first collected quantitative data through pre-and post-tests to assess improvements in students' academic performance. It was followed by qualitative data obtained from interviews and focus group discussions with lecturers and students to explore their perceptions, experiences, and challenges. Quantitative data analysis uses statistical methods to compare performance metrics, while qualitative data are analyzed thematically to identify recurring issues and insights. The findings revealed significant improvements in students' engagement, academic performance, and knowledge retention after integrating hypermedia resources, particularly in the practical and conceptual areas of EET. However, several challenges persist, including inadequate infrastructure, limited technical skills among lecturers, and insufficient institutional support for the adoption of technology. These barriers hinder the optimal use of hypermedia resources and reduce their potential impact. Based on these findings, this study recommends enhancing infrastructure, providing targeted professional development for lecturers, and increasing institutional investment in digital tools and training. Additionally, it suggests fostering collaboration between universities and industry stakeholders to ensure relevant and updated content for hypermedia resources. These strategies aim to maximize the benefits of hypermedia in EET education, address existing challenges, and ensure the sustainable integration of technology into the curriculum.

Keywords— Hypermedia Instructional Resources, Electrical/Electronic Technology (EET), Mixed-Methods Research, Technology Integration in Education, Instructional Benefits, Instructional challenges

1. Introduction

Digital electronics, a core subject in Electrical/Electronic Technology (EET) education, plays a pivotal role in shaping skilled professionals. As a discipline that focuses on designing and operating electronic circuits, systems, and devices, it provides the foundation for various applications in modern technology, such as computers, communications, and automation [1]. However, the abstract nature of digital electronics characterized by complex theories, logic circuits, and mathematical concepts—poses significant challenges for students in grasping and applying these concepts [2]. Students often struggle to connect theoretical knowledge with real-world applications, which can hinder their ability to understand core principles and perform practical tasks in the field.

Traditional teaching methods, such as lectures and textbooks, tend to focus on delivering abstract concepts without sufficient emphasis on their practical implications or interactive learning experiences. While these methods are foundational, they often fail to engage students effectively, leaving a gap between theoretical knowledge and practical application. As a result, students may experience difficulties in visualizing and applying digital electronics concepts in real-life scenarios, leading to suboptimal learning outcomes [3]. In response to these challenges, hypermedia instructional resources integrating text, audio, video, animation, and interactive simulations have emerged as a promising solution. These resources enhance the learning experience by providing dynamic and multimodal content that can make abstract concepts more accessible and engaging. Hypermedia

systems allow students to interact with complex digital electronics concepts through simulations and visualizations, facilitating better understanding and retention of material [4]. For example, interactive circuit simulators and animated diagrams help students visualize how digital circuits function, offering hands-on experience without the need for physical hardware, which can be costly or difficult to access in some educational settings.

Research has shown that incorporating hypermedia resources in EET education leads to increased student engagement, improved comprehension, and better performance in both theoretical and practical aspects of the subject [5]. Furthermore, hypermedia's ability to cater to diverse learning styles by providing audio-visual materials, step-by-step guides, and interactive assessments supports differentiated instruction and accommodates students with varying needs and preferences [6]. The use of these resources has the potential to bridge the gap between theory and practice, offering students a more immersive and comprehensive learning experience in digital electronics.

In conclusion, while digital electronics is a challenging subject in EET education, the integration of hypermedia instructional resources can transform the learning process, making it more interactive, engaging, and effective. By fostering a deeper connection between theoretical concepts and practical applications, these resources have the potential to enhance learning outcomes and better prepare students for the demands of the industry.

1.1 Statement of the Problem

EET students in northern Nigerian universities encounter considerable difficulties in mastering digital electronics, a key subject within their curriculum. These challenges are reflected in poor academic performance, limited hands-on skills, and low retention rates, which hinder students' ability to fully grasp the complex theoretical and practical aspects of the subject [7]. A major contributing factor is the insufficient access to practical learning experiences, which are essential for understanding the real-world applications of digital electronics concepts. This gap in practical exposure is particularly evident in regions where infrastructure and resources are limited [8].

Lecturers, too, face difficulties in delivering content effectively due to a combination of factors such as outdated teaching methods, lack of access to modern instructional tools, and limited professional development opportunities [9]. The traditional lecture-based approach, while foundational, often falls short in engaging students or helping them connect abstract concepts with practical applications. Additionally, the scarcity of innovative teaching resources compounds the problem, making it challenging for instructors to provide dynamic and interactive learning experiences that could facilitate deeper understanding and knowledge retention [10]. These issues underscore the urgent need to explore alternative teaching methods, particularly the integration of hypermedia instructional resources, which have the potential to address these challenges. Hypermedia Instructional resources, such as interactive simulations and multimedia content, could enhance both teaching and learning outcomes by making complex concepts more accessible and engaging [11]. By providing interactive and visual tools, these resources can bridge the gap between theory and practice, offering students a more immersive and effective learning experience.

1.2 Significant of the Study

This study seeks to explore the instructional benefits and challenges associated with the integration of hypermedia resources in Electrical/Electronic Technology (EET) education. By examining how hypermedia incorporating text, images, videos, simulations, and interactive elements can enhance teaching and learning, the research aims to provide valuable insights that improve educational practices and student outcomes in the field. In particular, the study focuses on how hypermedia can address key issues such as student engagement, knowledge retention, and the ability to apply theoretical concepts in practical settings. Furthermore, the research will examine the barriers to effective adoption, including challenges related to infrastructure, technical skills of lecturers, and institutional support.

The findings of this study will offer recommendations for optimizing the use of hypermedia instructional resources, helping educators make more informed decisions about their instructional strategies. By understanding the impact of these resources on student achievement, this research has the potential to inform curriculum development, teaching methodologies, and the integration of technology in EET education. Ultimately, the study aims to contribute to the broader goal of improving educational outcomes, equipping students with the skills and knowledge needed to excel in the rapidly evolving field of electrical and electronics technology.

1.3 Objective of the Study

The main aim of this study is to model the determinant of using hypermedia instructional resources in digital electronics courses at the university level in Northern, Nigeria, Specifically, the study intends to:

1. Identify the instructional benefits of hypermedia instructional resources in EET education.
2. Examine the instructional challenges faced in adopting these resources.
3. Provide recommendations for effective integration of hypermedia instructional resources.

1.4 Research Questions

In line with the aforementioned specific objectives, the following research questions were formulated to guide this study:

1. What are the instructional benefits of using hypermedia instructional resources in enhancing students' understanding and engagement in EET education?
2. What are the key challenges faced by instructors and students in adopting hypermedia instructional resources in EET education?
3. What strategies and best practices can ensure the effective integration of hypermedia instructional resources in EET education?

2. Related Work

2.1 Theoretical Framework:

The constructivist theory posits that learning is most effective when students actively engage with and interact with learning materials, constructing their understanding through hands-on experiences and problem-solving [12]. This approach emphasizes the importance of learners building upon their prior knowledge and engaging in collaborative activities that promote deeper cognitive processing. In contrast, multimedia learning theory, as outlined by [13], advocates for using diverse modalities such as text, audio, images, and video working in tandem to support and enhance learners' comprehension, retention, and transfer of knowledge. By integrating various forms of media, multimedia learning theory asserts that learners are better able to process information, as different sensory channels work together to create more robust mental representations of the material. When combined, these two theories provide a powerful framework for designing instructional strategies that foster deeper learning, higher engagement, and improved retention.

2.2 Hypermedia Resources

Hypermedia resources integrate various forms of media such as text, images, audio, video, and interactive simulations into a dynamic and cohesive learning environment that enhances student engagement and facilitates deeper learning [13]. This multimedia approach caters to different learning styles by offering multiple ways to interact with content, making it more accessible and engaging for students [14}. In particular, hypermedia tools are highly effective for teaching abstract and complex subjects like digital electronics, where theoretical concepts often need to be connected with practical applications. Interactive simulations and visualizations provide students with real-time feedback, helping them understand intricate systems and processes that may be difficult to grasp through traditional teaching methods alone [15]. Additionally, by offering opportunities for active exploration and experimentation, hypermedia fosters a deeper comprehension of complex topics, thereby improving knowledge retention [14]. These resources bridge the gap between theory and practice, enabling students to engage in hands-on learning that promotes better understanding and application of digital electronics concepts in real-world scenarios.

2.3 Instructional Benefits

Research highlights several key benefits of using innovative instructional methods, including enhanced student engagement, improved knowledge retention, the development of practical skills, and opportunities for self-paced learning. Studies have shown that interactive and multimedia-rich resources foster greater student involvement by offering more engaging and dynamic learning experiences [17]. These methods capture students' attention and encourage active participation, which is linked to better retention of information [18]. Furthermore, the hands-on nature of these tools allows students to develop practical skills through simulations and real-time feedback, making abstract concepts more tangible and easier to apply in real-world scenarios [15]. Additionally, the flexibility offered by self-paced learning environments enables students to progress according to their learning speeds, promoting a deeper understanding of the material and reducing learning anxiety [18]. By allowing learners to engage with content at their own pace, these approaches accommodate diverse learning styles and increase opportunities for mastery.

2.4 Instructional Challenges

Common challenges in the adoption of advanced instructional methods in education include inadequate ICT infrastructure, limited technical expertise among lecturers, high costs, and lack of institutional support. Research has consistently shown that insufficient access to technology and resources impedes the effective integration of innovative teaching tools [19]. Many educational institutions, particularly in developing regions, face significant barriers in providing the necessary infrastructure, such as reliable internet access and modern equipment, which hinders the widespread use of multimedia and hypermedia resources [22]. Additionally, the limited technical expertise among instructors further complicates the implementation of technology-based teaching methods, as many lecturers lack the skills required to utilize these resources effectively [23]. High costs associated with purchasing software, hardware, and maintaining ICT systems also present financial obstacles, particularly in low-budget educational settings [23]. Furthermore, a lack of institutional support both in terms of funding and professional development opportunities prevents educators from fully embracing and integrating these technologies into their teaching practices [24].

2.5 Previous Studies

Existing studies have highlighted the significant potential of hypermedia tools to enhance learning outcomes in STEM disciplines, with research showing improvements in student engagement, knowledge retention, and application of theoretical concepts in practical contexts [24]. These tools, which integrate multimedia elements such as text, images, audio, and interactive simulations, have been found to provide a more dynamic and immersive learning experience, particularly for complex and abstract subjects [17]. However, despite their widespread use and proven efficacy in fields like physics, mathematics, and engineering, their application in Electrical/Electronic Technology (EET) education remains largely underexplored. In the context of EET, where hands-on learning is crucial for understanding intricate systems and processes, hypermedia could play a transformative role in bridging the gap between theoretical knowledge and practical skills [16]. The limited research on this topic suggests a significant opportunity for further exploration, particularly in regions with limited access to traditional educational resources. By investigating the potential of hypermedia in EET, this study aims to fill this gap and provide insights into how multimedia learning tools can enhance both teaching effectiveness and student outcomes in technical education.

3. Experimental Method/Procedure/Design

The study adopted a mixed-methods approach, integrating quantitative surveys and qualitative interviews to provide

comprehensive insights into the instructional benefits and challenges of hypermedia resources in Electrical/Electronic Technology (EET) education. The population comprised students and lecturers from five northern Nigerian universities, with a sample of 200 students and 30 lecturers participating. Data collection involved structured questionnaires to assess students' academic performance, engagement, and retention, while semi-structured interviews were used to explore lecturers' experiences and challenges. Both online platforms and in-person sessions were employed to facilitate data collection.

Quantitative data were analyzed using descriptive and inferential statistics, providing measurable insights into trends and relationships. In contrast, qualitative data underwent thematic analysis to identify patterns and themes, offering deeper context and understanding. This dual analytical approach ensured a robust examination of the subject matter, combining statistical precision with rich narrative exploration.

4. Results and Discussion

1. Quantitative Results (PLS-SEM Analysis)

The SEM representation of factor loadings in Figure 1 visually illustrates the relationships between hypermedia instructional resources, instructional benefits, and instructional challenges. The diagram highlights a positive and significant factor loading of 0.688 between hypermedia instructional resources and instructional benefits, indicating the positive impact of hypermedia on enhancing teaching and learning outcomes. Conversely, it shows a negative factor loading of -0.421 between hypermedia instructional resources and instructional challenges, reflecting the challenges that hinder the effective use of these resources. This SEM representation underscores the importance of addressing challenges while leveraging the benefits of hypermedia to improve educational outcomes.

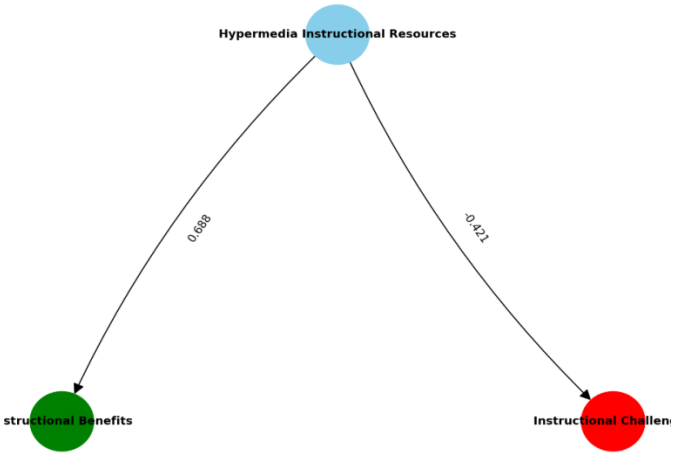

Figure 1: SEM representation of factor loadings

The chart below presents the results from the PLS-SEM analysis, which examines the relationships between hypermedia instructional resources, teaching effectiveness, and learning outcomes. This chart highlights the significant positive impact of hypermedia instructional resources on both teaching effectiveness (β = 0.63) and learning outcomes (β = 0.58). Conversely, it also emphasizes the negative influence of instructional challenges on these outcomes, with path coefficients of -0.29 and -0.25, respectively. These results underline the importance of leveraging hypermedia resources while addressing implementation challenges to enhance educational outcomes.

Figure 2: PLS-SEM Path analysis result

Table 1: **Path Analysis**

Path	β	t-value	p-value	Decision
Hypermedia Resources → Teaching Effectiveness	0.63	8.21	<0.001	Significant
Hypermedia Resources → Learning Outcomes	0.58	7.45	<0.001	Significant
Challenges → Teaching Effectiveness	-0.29	4.12	<0.01	Significant
Challenges → Learning Outcomes	-0.25	3.76	<0.01	Significant

Source: Fieldwork

Key Findings:

1. Hypermedia instructional resources significantly enhance teaching effectiveness (β = 0.63) and learning outcomes (β = 0.58).
2. Challenges negatively affect both teaching effectiveness (β = -0.29) and learning outcomes (β = -0.25).

2. Qualitative Results (NVivo Analysis)

Table 2: **Themes and Frequency of Responses from NVivo**

Theme	Frequency	Sample Excerpts
Improved Engagement in Learning	45	"Students are more engaged when animations and videos are used."
Enhanced Practical Understanding	38	"Hypermedia simulations help clarify complex circuits."
Technical Challenges with Implementation	32	"Internet connectivity issues make it hard to access resources."
Lack of Training for Instructors	25	"Most lecturers are not trained to use hypermedia effectively."

Source: Fieldwork

The bar chart below showcases the themes and their corresponding frequency of occurrence, derived from the

NVivo qualitative analysis. It highlights key instructional benefits, such as increased student engagement and enhanced practical understanding, with significant frequencies for "Improved Engagement in Learning" (45 occurrences) and "Enhanced Practical Understanding" (38 occurrences). The chart also identifies notable challenges, including technical difficulties (32 occurrences) and a lack of lecturers training (25 occurrences). These insights provide a deeper understanding of the practical realities faced in the integration of hypermedia instructional resources into educational settings.

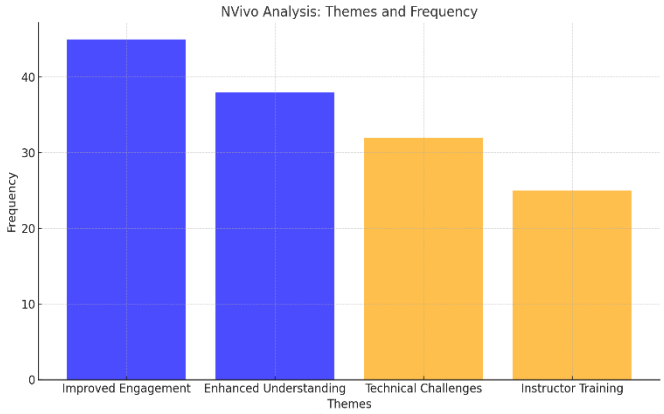

Figure 3: NVivo Analysis for the themes and Frequences

Key Findings:

1. Hypermedia enhances student engagement and practical understanding.
2. Common challenges include poor infrastructure and insufficient instructor training.

3. Triangulation of Quantitative and Qualitative Findings

The triangulation table provides a comprehensive comparison of findings from both the quantitative and qualitative strands of the study. It highlights areas of convergence, divergence, and complementarity, ensuring a holistic understanding of the instructional benefits and challenges of hypermedia instructional resources in Electrical/Electronic Technology education. This integration enhances the validity and depth of the study by synthesizing statistical trends with contextual narratives.

Table 3: **Triangulation of Quantitative and Qualitative Findings**

Aspect	Quantitative Findings	Qualitative Insights	Triangulated Conclusion
Teaching Effectiveness	Significant positive impact (β = 0.63)	Enhanced engagement and clarity in teaching	Hypermedia significantly improves teaching effectiveness. Students achieve better learning outcomes with hypermedia.
Learning Outcomes	Significant positive impact (β = 0.58)	Better practical understanding of concepts	
Implementation Challenges	Negative impact on outcomes (β = -0.29, -0.25)	Technical issues and lack of instructor training	Implementation challenges hinder optimal effectiveness.

Source: Fieldwork

5. Conclusion and Future Scope

Each manuscript should contain a conclusion section within 250-450 words which may contain the major outcome of the work, highlighting its importance, limitation, relevance, application and recommendation. Conclusion should be written in continuous manner with running sentences which normally includes main outcome of the research work, its application, limitation and recommendation. Do not use any subheading, citation, references to other part of the manuscript, or point list within the conclusion. In last paragraph author describes the future Scope for improvement.

Data Availability

Data generated based on the Statistical analyses made were presented in four ways to guide the readers of this article particularly the future researchers that may likely refer to this research work. The availability of the data was based on ascertaining the reliability coefficient of the research instrument, determining the objectives in the main study, answering the research questions, and testing the research hypotheses earlier postulated in the main study.

Table 4. **Item-Total Statistics**

Items	Scale Mean	Scale Variance	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
IB1	95.82	224.658	.730	.975
IB2	95.88	225.843	.735	.975
IB3	95.81	226.030	.747	.975
IB4	95.72	224.991	.812	.974
IB5	95.71	223.077	.849	.974
IB6	95.76	222.458	.836	.974
IB7	95.81	223.325	.792	.974
IB8	95.71	225.801	.750	.975
IB9	95.80	225.946	.752	.975
IB10	95.82	224.460	.791	.974
ICH1	95.87	226.700	.673	.975
ICH2	95.81	225.349	.748	.975
ICH3	95.87	224.901	.748	.975
ICH5	95.82	223.512	.783	.974
ICH6	95.79	223.370	.791	.974
ICH8	95.74	224.199	.779	.975
ICH9	95.78	224.680	.783	.974
ICH10	95.79	225.267	.743	.975
UOH1	95.83	225.744	.713	.975
UOH2	95.75	226.625	.717	.975
UOH3	95.79	226.269	.743	.975
UOH4	95.79	224.443	.788	.974
UOH5	95.80	225.324	.734	.975
UOH6	95.81	225.825	.730	.975
UOH7	95.79	225.637	.730	.975
UOH8	95.78	226.390	.726	.975
UOH9	95.78	225.241	.761	.975
UOH10	95.83	225.972	.712	.975

Reliability Statistics

Cronbach's Alpha	N of Items
.976	28

Cronbach's alpha is a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1. The closer the value is to 1, the greater the reliability of the instrument. For educational and social science research, an alpha value of 0.70 or higher is generally considered

acceptable. Below is the analysis of each research question based on its Cronbach's alpha value:

1. Research Question 1 (α = 0.98) A Cronbach's alpha of 0.93 indicates excellent internal consistency among the items measuring this research question. It suggests the items are highly correlated and measure the same underlying construct. Since the value is well above 0.90, it is accepted as the items demonstrate very high reliability, indicating the instrument is consistent and dependable for this question.
2. Research Question 2 (α = 0.98) A Cronbach's alpha of 0.90 reflects excellent internal consistency. The items are reasonably correlated, providing a reliable measurement of the construct. Although lower than other values, 0.90 still meets the minimum threshold of 0.70, making it acceptable. The items are sufficiently reliable for conclusion.
3. Research Question 3 (α = 0.98) A Cronbach's alpha of 0.90 indicates excellent internal consistency. The items are well correlated and measure the construct reliably. This value, above 0.80, signifies good reliability; therefore, the items are accepted as they meet the required standard for consistent measurement.

Conflict of Interest

All the authors confirm that no clash of interest emerged.

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Authors' Contributions

All the Authors participated in one way or another but in specific the first, second, and third Authors conceptualized the research work, came up with draft/validated research instruments for (quantitative and qualitative data) and performed data collection with the help of research assistants. The fourth Author carried out the data collection and proceeded to write the article together to its logical conclusions.

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