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SIMULATION PROGRAM WITH INTEGRATED CIRCUIT EMPHASIS INCREASES CIRCUIT DESIGN SKILLS AMONG ELECTRICAL ENGINEERING STUDENTS IN EDO STATE POLYTECHNIC, USEN, EDO STATE, NIGERIA

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Abstract
To bridge the gap between the worlds of circuit design and chip fabrication, SPICE (Simulation Program with Integrated Circuit Emphasis) models have emerged as a critical player. The program is integrated into electronic engineering to simulate the problematic principles of analog modulation using superb free simulation software. The present study examined the role of the Pspice simulation program in developing engineering students' circuit design skills. The study participants included one hundred and eighty-seven (n = 187) students in the electrical engineering department at Edo State Polytechnic in Usen, Edo State, Nigeria. The participants' ages ranged from 23 to 31 years old, with a mean age of (M=9.14) and a standard deviation of (SD=1.24). They were separated into two groups, with group (A) as the experimental condition. On the other hand, group (B) is the condition that serves as the control. A t-test analysis was performed on the data to answer the research question of whether the Pspice simulation software would increase students' skills in circuit design. The research found that circuit design skills were significantly different under the experimental settings compared to the control conditions (MD = 5.08, t (185) = 7.328, p =.000). Consequently, the findings answered the study's research question. The finding suggests that SPICE might be utilized to enhance students' circuit design skills. Implications and suggestions for application are presented.

Keywords: SPICE, circuit design, students, skills

Introduction

The world of electrical circuit design and optimization has witnessed significant advancements in recent years, mainly due to the remarkable benefits offered by circuit simulators. Computer simulations, which contain visual elements for simulating real-world systems or phenomena, have been acknowledged as an efficient method for education and training in the scientific disciplines (Duangngoen & Srisawasdi, 2016). Virtual reality simulators are becoming essential to modern education (Roy et al., 2017). Numerous computer programs to solve common and uncommon problems have been produced due to these advancements. These programs help plan, create, and manage complex systems using the computer's enhanced computational capabilities. Various teaching methods are emerging, and virtual simulation technology as a new teaching medium has begun appearing in education and teaching (Yu & Chen, 2022). The use of virtual simulation technology to help students visualize the landscape space in front of students is of great help to students' spatial cognitive learning (Zhang & Ma, 2022). Virtual learning simulations are being employed as a supplement to traditional educational approaches in a variety of educational and training environments (Badowski & Wells-Beede, 2022; Behmadi et al., 2022; de Vries & May 2019; Foronda et al., 2020; Garmaise-Yee et al., 2022; McGarr, 2020; Moscato & Altschuller, 2019; Nassar & Tekian, 2020; Padilha et al., 2019; Perez et al., 2022; Qiao et al., 2021). Similarly, previous research has underscored its educational benefits (Dyrberg et al., 2017; Khan et al., 2018; Soraya et al., 2022; Wertz, 2022).

It has been argued that students' understanding of scientific ideas and concepts is based on their engagement in science and engineering practices (Papakonstantinou & Skoumios, 2021). Computer simulations enable students to instantly engage with genuine circumstances that may not be possible to encounter in real life due to their danger or rarity (Wang et al., 2014). Literature suggests that virtual learning simulations allow students to observe supposedly unobservable phenomena, reduce the time commitment of experiments that would take a very long time if carried out physically, and provide online and dynamic guidance (De Jong et al., 2013). Virtual learning simulations can promote learning in a novel way by assisting students in building an understanding of concepts and processes through inquiry-based learning and participation in realistic investigations with continuous feedback (Bonde et al., 2014; Furtak et al., 2012). Circuit simulators are sophisticated tools that allow engineers and designers to mimic the behavior of electrical circuits under various conditions without requiring actual prototypes. This enables thorough testing and analysis, which saves time and resources during the design phase. These simulators can precisely forecast circuit performance and provide vital insights into their behavior, enabling quick and successful troubleshooting.

The capacity of circuit simulators to discover design problems and optimize circuit performance is one of their primary advantages. Engineers can easily spot possible faults and make iterative modifications to the circuit design by modeling various scenarios. This repeated method aids in optimizing circuit performance, lowering the likelihood of failure, and maintaining efficient functionality. Numerous simulation modules support basic electronic practices based on virtual laboratories. For example, several studies have employed Proteus (Waluyo et al., 2021), Multisim (Djalal & HR, 2019), MatLab (Benotsmane et al., 2020) LabView (Korgin et al., 2019), and PSPICE (Muchlas & Budiastuti, 2020) software as a virtual laboratory on basic electronics subjects. The present study aimed to strengthen interest in circuit design using PSPICE simulation software.

Spice (Simulation Program with Integrated Circuit Emphasis) simulators are one of the most used circuit simulation tools. They are based on the SPICE language, a standardized format for describing electrical circuits. Spice-based simulators provide accurate transistor-level simulation and are particularly useful for analog and mixed-signal circuit designs. PSPICE is the SPICE software version created by MicroSim Company. It allows users to build a virtual circuit using a schematic, simulate it using different problem-solving strategies, and evaluate the results using the software. A circuit can be simulated in five main steps. In order to create a circuit, different parts from the directory are first inserted, then the parts are arranged, and then wires are connected between them. The names, values, and other part attributes are then changed. After saving, the schematic file is checked for errors. The outputs are then viewed and analyzed.

Circuit simulators allow for easy modification of component values to optimize circuit performance. Users can adjust resistance, capacitance, and other components to fine-tune circuit characteristics and meet specific design requirements. Simulations provide real-time feedback, allowing designers to iterate and optimize their designs quickly. Although circuit simulators have shown great promise, many questions about their potential exist. For instance, little is known about the effect of circuit simulators in improving circuit design skills in the Nigerian context. Therefore, the present study fills this gap by investigating circuit simulators as scarcely explored software programs that could increase students' skills in circuit design.

Research question: Will a simulation program with integrated circuit emphasis increase circuit design skills among Electrical Engineering Students at Edo State Polytechnic?

Method

The present study employed a quasi-experimental design with pre-test and post-tests and two groups (experimental and control conditions). One hundred and eighty-seven (n = 187) students enrolled in the electrical engineering department at Edo State Polytechnic in Usen, Edo State, Nigeria, comprising males and females between the ages of 23 and 31 years with a mean age of (M=9.14) and (SD= 1.24) were randomly selected as the study participants. They were assigned two conditions, with group A as the experimental condition. On the other hand, group B represents the control condition.

Procedure

The necessary permission had been secured from the school administration. This helped the researcher to acquire the participants' trust. The students participated in a pre-experiment survey by completing a questionnaire. Students' skills in circuit design were evaluated in a preliminary test. After the preliminary test was over, the research assistants gathered the questionnaires, tabulated the results, and turned them over to the researcher. The primary study resumed with the experimental conditions being taught circuit design with the Spice software. In contrast, the control conditions were taught the same lesson using the conventional method. Finally, the post-test study was conducted similarly to the pre-test, except the questions were reshuffled. The data from the pre-test and post-test were subjected to data analysis.

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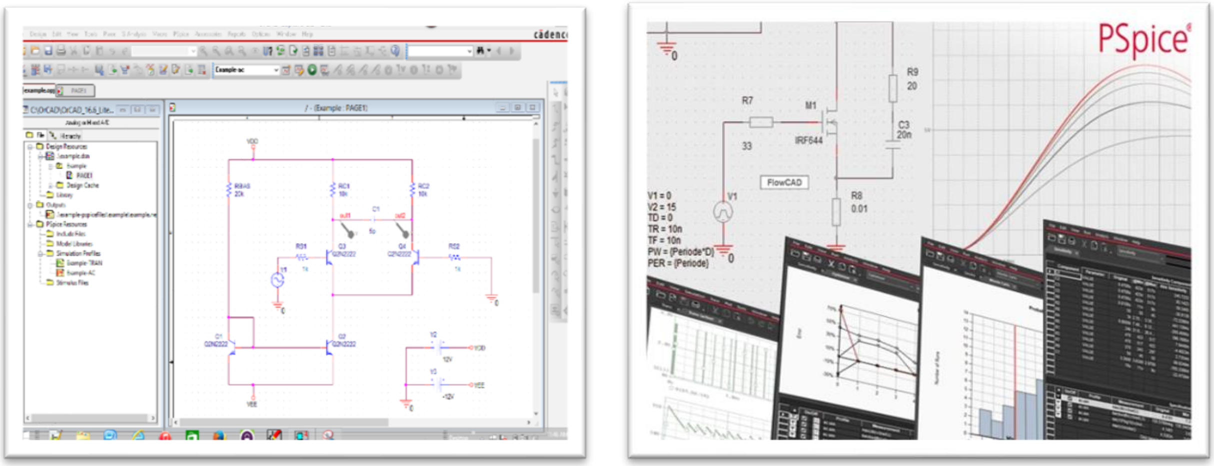

Fig 1: SPICE Training Interface

Result

Table 1 shows the mean and standard deviation scores for the group.

		Pre-test		Post-test		
Group	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean Gain
Experimental	98	43.17	10.54	50.19	13.68	7.02
Control	89	42.29	11.29	44.39	13.38	2.01
MD		0.88		5.08		

Table 1 shows that the mean in the pre-test study for experimental conditions is 43.17 while the mean in the pre-test for control conditions is 42.29, giving the pre-test mean difference of 0.88. The finding indicates no significant difference in the participants' mean scores on their level of interest in circuit design. On the other hand, the post-test study reveals a mean of 50.19 for the experimental conditions and 44.39 for the control condition, with a mean difference of 5.08. The gain score for the two conditions was 7.02 and 2.01, respectively. Thus, the result shows that the experimental conditions improved interest in circuit design due to their exposure to the SPICE software.

Table 2 shows a t-test comparison.

Source of variation	N	Mean	SD	df	*t*	Sig
Experimental	98	50.19	13.68			
Control	89	44.39	13.38	185	7.328	000

A t-test analysis was performed on the data to answer the research question of whether the SPICE simulation software would increase students' interest in circuit design. The analysis established a significant difference between the experimental and control conditions on interest in circuit design *MD* = 5.08, t (185) = 7.328, p = .000. Thus, the result provided the answer to the research question and suggested that the SPICE software might be used to improve student's interest in circuit design.

Discussion

This study examined the role of simulation programs with integrated circuit emphasis in increasing circuit design skills among Electrical Engineering Students at Edo State Polytechnic, Usen, Edo State, Nigeria. The result showed a significant difference between the students taught with the simulation software and those prepared with conventional methods in circuit design skills. For the pre-test and the post-test study conducted, the mean and standard deviation scores showed that exposing the students to a simulation program with integrated circuit emphasis significantly influenced their circuit design skills in the post-test study (*M* = 50.19, *SD* = 13.68) compared to the control group (*M* = 44.39, *SD* = 13.38). The probable explanation for this outcome is that simulating circuits and analyzing their

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behavior potentiates a deeper understanding of electronic concepts. Thus, users can explore the relationships between voltage, current, and resistance, observe the effects of different components, and investigate circuit characteristics such as resonance, filtering, and amplification. Circuit simulators act as a bridge between theoretical concepts and practical applications.

Furthermore, the findings back up the current trend toward learning strategies that rely more heavily on technology (Cristol et al., 2015) and add to the existing empirical evidence demonstrating the benefits of educational simulations in learning (Akselbo et al., 2020; Davis, 2019; Khan et al., 2019; Makransky & Petersen, 2019; McCoy et al., 2016; Scahill et al., 2021). In addition to confirming findings on learning, the present study revealed intriguing shifts in the approach to learning.

The implication of the study

The research findings have some implications for the teachers, students, school authorities, and curriculum planners. Indeed, the finding indicates that the circuit simulators have significant educational value, providing an interactive and practical learning platform for electronics education. Also, this has implications for all the stakeholders in education with inclusive students. More so, it implies that the teachers' continuous use of the conventional method in circuit design might slow learning capabilities. It equally means that if school authorities and curriculum planners do not try to enforce the use of simulation software, interest may be dampened.

Conclusion

The present research investigated whether SPICE simulation software will enhance students' circuit design skills. The research established a positive difference between the two conditions on circuit design skills in the post-test study. Thus, the study concludes that the SPICE simulation software is an essential technological tool that could improve students' overall skill in electronic circuit design. Therefore, the study contributes to the literature by supporting previous research that promotes the integration of simulation software in the classroom. Nevertheless, the sample size used in the study may pose a significant challenge for generalizing this result. Future researchers should include more representative samples and explore other moderating variables that could broaden our understanding of this outcome. However, the study recommends fully integrating SPICE resources in the classroom and consistently training instructors in this direction.

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