Intervention:
Targeted Learning
AC Circuits

By Shafiq R

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Targeted Learning Intervention Report: AC Circuits

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Introduction

The topic of Alternating Current (AC) Circuits is a core component of the Malaysian Matriculation Physics curriculum. It introduces students to foundational electrical principles relevant to domestic and industrial power systems. Understanding AC circuits is crucial not only for academic progression but also for practical comprehension of real-world applications such as the functioning of electrical appliances, transmission lines, and the national grid. This topic integrates knowledge of voltage, current, resistance, reactance, impedance, and power in time-varying conditions.

Background and Rationale

Three students, aged between 18 and 19, were selected based on consistently low performance in class exercises and formative assessments relating to AC circuits. Diagnostic probing revealed misconceptions such as confusion between peak and RMS values, incorrect use of Ohm's Law in AC contexts, and difficulty visualizing and calculating impedance in circuits with resistive and reactive components. These gaps were reinforced by weak conceptual links and procedural errors, particularly in applying correct formulas and interpreting results in context. The intervention aimed to clarify these misconceptions and enhance their problem-solving ability in AC circuit calculations.

Methodology

The intervention involved a structured approach with diagnostic, instructional, and evaluative components. Students undertook a pre-test consisting of five structured calculation questions aligned with key learning objectives in the topic. Each question carried three marks, totaling 15. Marks were allocated as follows: one mark for correct substitution of formulas, and two marks for the correct final answer, including appropriate units. Partial marks were awarded for intermediate accuracy.

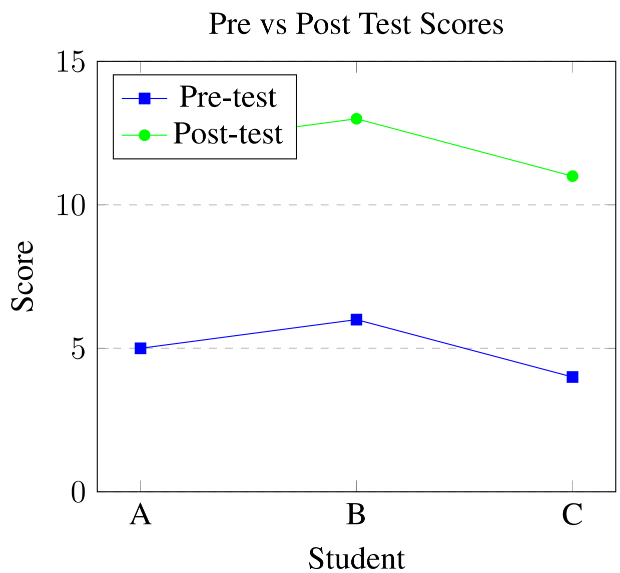
Resources employed included a custom-designed worksheet and a PhET Interactive Simulation for AC Circuits. These allowed students to visualize and manipulate circuit parameters, reinforcing conceptual learning through experiential interaction. Instruction was delivered through guided examples, with the educator modeling problem-solving steps and emphasizing conceptual understanding. Students then engaged in group-based discussion and practice, followed by individual attempts under supervision. Immediate feedback and clarification were provided.

Results, Analysis and Discussion

Student	Pre-test Score (/15)	Post-test Score (/15)	Normalized Gain
A	5	12	0.78
B	6	13	0.88
C	4	11	0.78

Normalized gain was calculated using the formula:

$$g = \frac{\text{Post} - \text{Pre}}{15 - \text{Pre}}$$



The intervention was successful in significantly improving student performance. All students demonstrated marked improvement in their scores, with normalized gains above 0.7 indicating high learning efficacy. The use of simulations enabled dynamic visualization of abstract concepts, which helped to correct faulty mental models of AC behavior. Furthermore, collaborative learning and step-by-step modeling provided cognitive scaffolding necessary for improved procedural execution. Students particularly benefited from real-time feedback and peer discussion, which allowed them to correct their misunderstandings through interaction and guidance.

Conclusion

This intervention confirmed that a targeted and structured approach, integrating diagnostic assessments, visual tools, guided practice, and immediate feedback, can meaningfully enhance conceptual and procedural understanding in AC circuits. The methods and materials used are easily replicable and adaptable to larger groups or similar topics involving abstract or multi-step calculations. Continued use of interactive tools, along with peer-supported problem solving, is recommended for topics requiring strong visual and procedural integration.

Appendix A: Pre and Post Test Questions

1. Calculate the RMS voltage of a 240 V peak AC supply.
2. A coil has resistance 4 Ω and reactance 3 Ω. Find the impedance.
3. Find current through an AC circuit with 120 V RMS and total impedance of 10 Ω.
4. Determine the power dissipated in an AC circuit with 5 A RMS current and 20 Ω resistance.
5. An AC circuit has a 50 Hz frequency and a capacitor of 100μF. Find capacitive reactance.

Appendix B: Marking Scheme with Step-by-step Solutions

Q1 $V_{\text{RMS}} = \frac{240}{\sqrt{2}}$ (1 mark for correct formula substitution)

$= \boxed{169.7 \text{ V}}$ (2 marks for final answer with units)

Q2 $Z = \sqrt{4^2 + 3^2}$ (1 mark)

$= \sqrt{16 + 9}$

$= \boxed{5\ \Omega}$ (2 marks)

Q3 $I = \frac{120}{10}$ (1 mark)

$= \boxed{12 \text{ A}}$ (2 marks)

Q4 $P = I^2 R = 5^2 \times 20$ (1 mark)

$= 25 \times 20 = \boxed{500 \text{ W}}$ (2 marks)

Q5 $X_C = \frac{1}{2\pi f C}$ (1 mark)

$= \frac{1}{2\pi(50)(100\times10^{-6})}$

$= \boxed{31.8\ \Omega}$ (2 marks)

Appendix C: Intervention Worksheet with Answers

1. What is the frequency of an AC supply with a time period of 0.02 s?
   $$\boxed{f = \frac{1}{T} = \frac{1}{0.02} = 50 \text{ Hz}}$$
2. A resistor and capacitor are connected in series to a 100 V RMS supply. If $R = 10\ \Omega$ and $X_C = 20\ \Omega$, find the impedance.
   $$\boxed{Z = \sqrt{R^2 + X_C^2} = \sqrt{10^2 + 20^2} = 22.4\ \Omega}$$
3. Calculate the RMS current in the circuit above.
   $$\boxed{I = \frac{V}{Z} = \frac{100}{22.4} = 4.46 \text{ A}}$$
4. Calculate the peak voltage from an RMS value of 170 V.
   $$\boxed{V_p = \sqrt{2} \times V_{RMS} = 1.414 \times 170 = 240.4 \text{ V}}$$
5. Determine the phase angle in a circuit with $R = 10\ \Omega$, $X_L = 10\ \Omega$.
   $$\boxed{\tan\phi = \frac{X_L}{R} = 1 \Rightarrow \phi = 45^\circ}$$

Appendix D: Explanation of Teaching Tools

The PhET Interactive Simulation ”AC Circuit Construction Kit” was employed to support visual and conceptual understanding. Students used the simulation to build circuits with resistors, capacitors, and inductors, observing how current and voltage respond to changes in frequency, resistance, and capacitance. The simulation allowed real-time manipulation and provided graphs of voltage and current over time, helping students visualize the phase difference and amplitude relationships crucial to AC behavior. This tool was integrated with verbal explanation and worksheet tasks to ensure conceptual reinforcement.

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