Intervention Report: Structured Momentum Solving via Table Method

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Intervention: Table - Momentum

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1 Introduction

This report documents a learning intervention designed to improve students' ability to solve physics problems involving the conservation of momentum using a structured table-based method. The intervention was carried out with a small group of students from a Malaysian Matriculation College who had demonstrated weak performance in prior assessments.

2 Background

Momentum conservation problems often pose significant conceptual and analytical challenges for pre-university physics students. Prior quiz analysis revealed that several students struggled to organize known and unknown quantities, especially in two-dimensional problems. These issues frequently led to errors in identifying the direction of momentum components and applying vector addition principles correctly.

To address this, a table-based approach was introduced. This strategy has been informally used in tutorials but not systematically implemented as a structured intervention. This report describes the implementation and evaluates its effectiveness.

3 Theoretical Framework

The intervention is grounded in the following pedagogical principles:

- **Cognitive Load Theory:** Structuring problem-solving through tables helps reduce extraneous load by organizing information spatially.
- **Constructivism:** Students build new knowledge more effectively when they actively reorganize concepts and patterns through structured formats.
- **Scaffolding:** Providing a step-by-step method offers temporary support that can later be internalized.

These principles align with Malaysia's national STEM and Matriculation Programme learning outcomes emphasizing analytical thinking and effective scientific communication.

4 Intervention Design

4.1 Participants

Five students were selected from a matriculation physics class based on poor performance (scoring below 40%) in a prior momentum quiz.

4.2 Duration and Structure

The intervention consisted of two sessions, each lasting one hour, conducted on consecutive days:

- **Session 1:** Introduction to the table-based method using simple 1D momentum problems.
- **Session 2:** Application to 2D problems with teacher-guided and peer-collaborative practice.

4.3 Objectives

- Improve students' ability to correctly apply the law of conservation of momentum.
- Help students systematically organize problem information and vector components.
- Enhance students' confidence and accuracy in solving momentum problems.

4.4 Method and Procedure

1. Preparation:

- Teacher prepares printed worksheets (see Appendix) with guided tables.
- Whiteboard and markers are used to model solutions.

2. Teaching the Method:

1. Each problem begins by identifying all objects involved in the collision.
2. A table is created with columns for each object and rows for initial momentum (x and y), final momentum (x and y), and total momentum.
3. Students fill in known values and mark unknowns.
4. Use the conservation principle: total initial momentum = total final momentum (separately for x and y directions).
5. Solve algebraically and interpret physically.

3. Collaborative Work:

- Students work in pairs to complete practice problems.
- The teacher circulates to guide misconceptions and encourage discussion.

4. Feedback and Reflection:

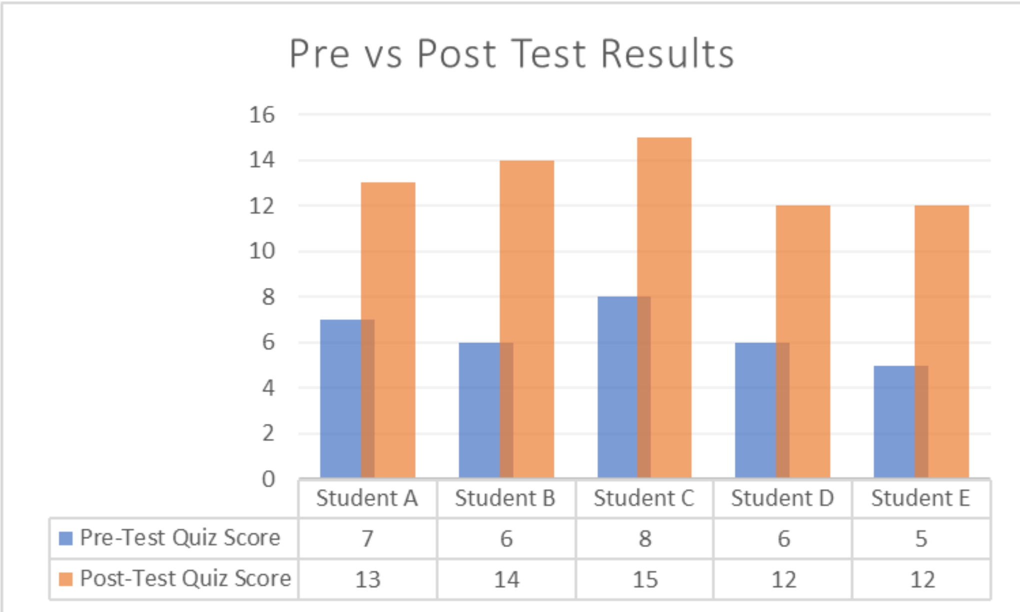
- End of session includes a 5-minute debrief where students reflect on their understanding and problem-solving approach.

5 Results and Analysis

5.1 Performance Improvement

A post-intervention quiz with similar structure and difficulty was administered. The results showed a marked improvement:

Student	Pre-Test Score (/20)	Post-Test Score (/20)
A	7	13
B	6	14
C	8	15
D	6	12
E	5	12



5.2 Quantitative Results:

All five students showed improvement in their test scores following the intervention. The average pre-test score was 6.4 out of 20, while the average post-test score rose to 13.2 out of 20. This represents more than a 100% increase in mean performance. Student B showed the most significant individual gain, improving by 8 marks, while Student C, who had the highest pre-test score, continued to improve to a near-perfect score. The consistency in gains across all students suggests the intervention was effective in addressing the core difficulties in momentum problem solving.

5.3 Qualitative Observations

- Students exhibited increased willingness to attempt 2D problems.
- Misconceptions related to direction and sign conventions decreased.
- Peer discussion and table-filling prompted deeper engagement with vector concepts.

6 Conclusion and Recommendations

This targeted intervention using the table-based method improved students' problem-solving ability and confidence in applying the conservation of momentum. The structure helped reduce cognitive overload and allowed students to focus on reasoning.

Recommendations:

- Integrate the table-based method early in the topic.
- Use it for both instruction and assessment.
- Encourage peer teaching using this structure.

Future research may expand to a larger cohort and assess long-term retention.

Appendix A: Intervention Worksheet

Instructions: Fill in the following table for each momentum problem.

Quantity	**Object A (x)**	**Object A (y)**	**Object B (x)**	**Object B (y)**
Initial Momentum				
Final Momentum				
Total Momentum				

Repeat for each problem. Discuss with your partner how each value is obtained.

Appendix B: Pre- and Post-Test Questions and Solutions

Marking Scheme: Each correct value filled in the table = 1 mark; Final correct answer = 1 mark; Total = 20 marks.

Pre-Test Question

Two carts collide on a frictionless track. Cart A (2.0 kg) moves at 3.0 m/s to the right and Cart B (3.0 kg) moves at 2.0 m/s to the left. After the collision, they stick together. Find the final velocity of the combined mass.

Step-by-Step Solution:

- Initial momentum A = $2.0 \times 3.0 = +6.0$ kg m/s
- Initial momentum B = $3.0 \times (-2.0) = -6.0$ kg m/s
- Total initial momentum = 0
- Total final mass = 5.0 kg
- Final velocity = 0 / 5.0 = 0 m/s

Post-Test Question

A 2.0 kg object moves east at 4.0 m/s and collides with a stationary 3.0 kg object. After the collision, the 2.0 kg object moves at 1.0 m/s at 30° north of east. Find the final velocity (magnitude and direction) of the 3.0 kg object.

Step-by-Step Solution:

- Initial momentum A (x) = $2.0 \times 4.0 = 8.0$ kg m/s
- Initial momentum A (y) = 0
- Initial momentum B = 0
- Final momentum A (x) = $2.0 \times 1.0 \times \cos(30°) = 1.732$ kg m/s
- Final momentum A (y) = $2.0 \times 1.0 \times \sin(30°) = 1.0$ kg m/s
- Final momentum B (x) = $8.0 - 1.732 = 6.268$ kg m/s
- Final momentum B (y) = $0 - 1.0 = -1.0$ kg m/s
- Velocity B (x) = 6.268 / 3.0 = 2.089 m/s
- Velocity B (y) = –1.0 / 3.0 = –0.333 m/s
- Magnitude = $\sqrt{(2.089)^2 + (-0.333)^2} = 2.115$ m/s
- Angle = arctan(0.333 / 2.089) = 9.1° south of east