

Diagnostic Analysis of Students' Errors in Integral Calculus

Method Selection as a Source of Difficulty in Undergraduate Mathematics

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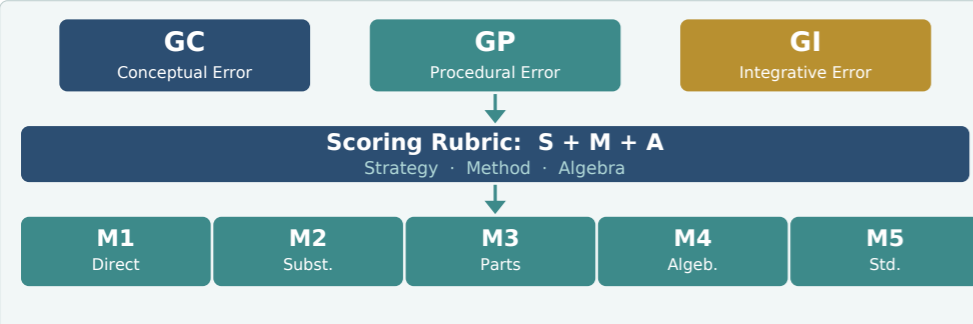
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KEY FINDING: The primary difficulty is not computing integrals — it is the structural recognition required to select an appropriate integration method.

1. Background

- Students can often execute integration techniques.
- Difficulty arises in selecting the appropriate method.
- Familiar methods are applied without structural analysis.
- Procedural fluency does not guarantee structural understanding.

2. Conceptual Framework



3. Math in Action

✗ Wrong approach
 $\int x e^x dx$

Student: substitution
 $u = x, du = dx$
 → circular result
 → no progress
GC error: structure misread

✓ Correct approach
 $\int x e^x dx$

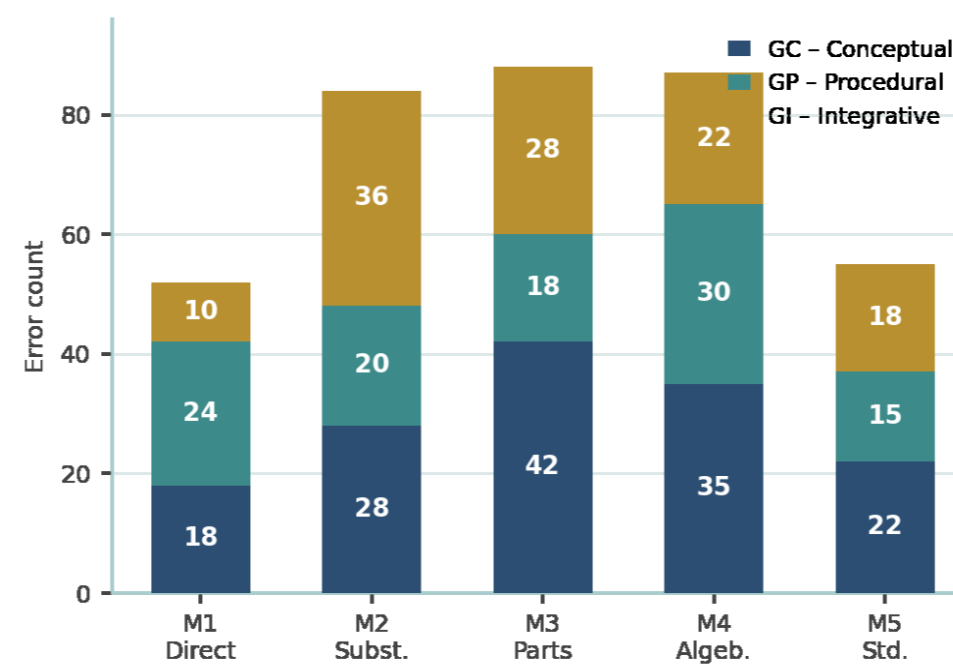
Method: integration by parts
 $u = x, dv = e^x dx$
 $du = dx, v = e^x$
 $\int x e^x dx = x e^x - \int e^x dx$
 $= x e^x - e^x + C$
 $= e^x(x - 1) + C$ ✓

Illustrative GC error: substitution selected instead of integration by parts after integral structure is misread.

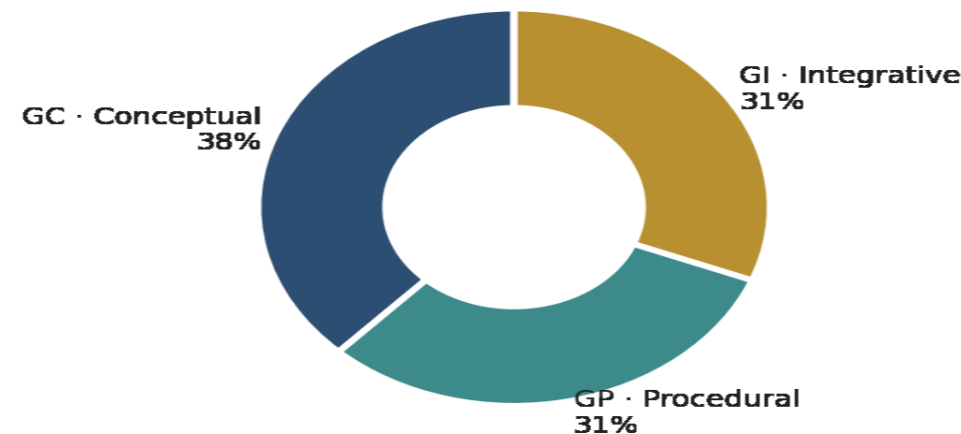
4. Methodology

Design: Diagnostic, quantitative
Participants: First-year calculus students
Instrument: 5 tasks × 5 integration methods
Scoring: S+M+A rubric (0-3 per item)
Analysis: Error frequency by type and method

5. Error Frequency by Method



6. Overall Error Distribution



7. Research Questions

- RQ1.** Which methods generate the highest error rates?
- RQ2.** Which error types predominate by integration method?
- RQ3.** Which student profiles are most at risk?

8. Key Findings

- M3 (integration by parts): highest error rate, GC-dominant.
- M2 (substitution): most frequently misapplied method.
- Conceptual errors account for 38% of recorded errors.
- Strategy score (S): weakest component across all groups.
- M4 and M5 are rarely attempted by first-year students.
- Limited transfer from pre-university procedural to tertiary structural reasoning.

9. Pedagogical Implications

Structural Recognition

Analyse integral form before selecting a method.

Method Comparison

Compare multiple approaches to the same integral.

Diagnostic Assessment

Use error-provoking tasks for formative assessment.

10. Conclusion

- Method selection requires explicit instructional attention.
- The S+M+A rubric enables fine-grained diagnostic analysis.
- Targeted diagnostic tasks may support improved structural recognition and method selection.

References

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