College Students’ Retention and Transfer from Calculus to Physics

Lili Cui
N. Sanjay Rebello
Andrew G. Bennett
Kansas State University

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Research Question

• To what extent do students retain and transfer their calculus knowledge when solving problems in introductory physics?

• What difficulties pertaining to the transfer of calculus do students have while solving these problems?

• What strategies may help students overcome these difficulties?

Transfer

• Transfer is often defined as the ability to apply what has been learned in one context to a new context1

• Methods to assess transfer
  – One-shot assessments such as performance on tests and examinations
  – Graduated prompting2

One to One Think Aloud Interview
Fall 2004

• Engineering Physics-II students
  – Eight male volunteers
  – Sophomores
  – Mech. Engr. majors

• Two sessions
  – About one hour long
  – Solve two physics problems
  – Solve isomorphic calculus problems
  – General questions about calculus background and application of their calculus knowledge in physics

Variations of Physics Problems

Variation of “E field caused by a half-circle charge distribution” question

Variation of “Magnetic field caused by a non-constant current distribution” question

Variation of “Induced current caused by moving loop in a changing magnetic field” question

One to One Think Aloud Interview
Spring 2005

• Engineering Physics-II students
  – Five male, three female, various majors

• For each session (two session total):
  – Similar format as Fall 2004
  – Do not solve pure calculus problem
  – Solve sets of variation of physics problem to explore the criteria use “integration” instead of “summation”

Focus on exploring the origin of difficulties


Variations of Physics Problems

Variation of “E field caused by a half-circle charge distribution” question

Variation of “Magnetic field caused by a non-constant current distribution” question

Variation of “Induced current caused by moving loop in a changing magnetic field” question
Results—Fall 2004

- Self-confidence in calculus knowledge retention
- Realization that calculus is required in physics
- Lack of confidence in setting-up physics problems

Students’ self-reflections are consistent with our observations.

Results—Spring 2005

- Consistent with previous interview results
- Criterion on use of integration in physics
  - When problems were similar to the examples seen in the text (4 out of 7 interviewees)
    - Could not explain why they use integration
    - Could not solve the variations physics problems
  - Used integration to add up infinitesimally small elements (3 out of 7)

Results—Spring 2005

- Difficulties when applying integrals
  - Determining the variable of integration
    - “all constants (variables), I do not know what I should integrate although I know how to integrate…”
  - Deciding the limits of integration
    - Students usually did not realize they used the wrong limits
  - Origin of difficulties
    - Physics class (majority)
    - Calculus class

Results—Spring 2005

- Prefer to use pre-derived algebraic relationships instead of applying calculus
- Unaware of the conditions in which integration was needed.
- Using calculus in physics is more just ‘plug and chug’ than understanding

To facilitate transfer between calculus and physics...

- More ‘word’ problems in calculus to help visualization
- More emphasis on learning how to set-up physics problems
- Focus on understanding (calculus and physics)
- Take calculus and physics concurrently

Conclusions

- Students believed that for the most part their calculus class has provided them with adequate knowledge and skills required for physics
- Students believed they did transfer their calculus knowledge when solving calculus-based physics problems although they had difficulties
- Students need external clues to facilitate the transfer process.
Further Work

• Design a quantitative investigation of students’ performance on calculus-based physics problems on exams to examine the transfer in large populations.

For More Information...

Lili Cui
Kansas State University
lili@phys.ksu.edu
(785)532-7167