College Students' Retention and Transfer from Calculus to Physics

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1

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?

2

Transfer

- Transfer is often defined as the ability to apply what has been learned in one context to a new context[1]
- Methods to assess transfer
  - One-shot assessments such as performance on tests and examinations
  - Graduated prompting[2] → Interview

[1]Byrnes (1996) [2]Newmann (1989)

3

One to One Think Aloud Interview Fall 2004

- Engineering Physics-II students
  - Eight male volunteers
  - Sophomores.
  - Mech. Engr. majors
- Two sessions
- For each session:
  - 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

1) E field caused by a half-circle charge distribution
2) Electric potential caused by changing E field
3) B field caused by a non-constant current distribution
4) Induced current caused by moving of the loop in a changing magnetic field

4

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"

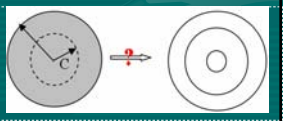
Focus on exploring the origin of difficulties

5

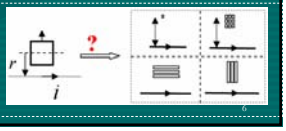
Variations of Physics Problems

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



6

Results—Fall 2004

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

Role of calculus???

Students' self-reflections are consistent with our observations.

7

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)

8

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

9

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

10

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

11

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.

12

Further Work

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

13

For More Information…

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14