TRANSFER OF LEARNING from College Calculus to Physics Courses

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Motivation

- Students need to apply what they have learned in one class to another class.

- Students must *be prepared* to apply what they have learned in school to the real world.

Transfer of Learning

- 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)

Research Questions

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

Phase I

- What difficulties pertaining to the transfer of calculus do students have while solving these problems?
- What strategies may help students overcome these difficulties?

Phase II

Phase I: Fall 2004

Individual Think Aloud Interview

- Participants
  - 8 students, volunteer,
  - Most second year in
  - Major in Mechanical
- Video-taped
- Two sessions
- For each session:
  - About one hour l ng
  - Solve two physics problems
  - Solve isomorphic calculus problems
  - General questions about calculus background and application of their calculus knowledge in physics

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

Results: Phase I (1 of 2)

- Self-confidence in calculus knowledge retention

"have done it so many times…" "remember well…"

- Realization that calculus is required in physics

"because it would teach you the basic mathematics, but at some point, I need them to teach me the different aspects as what's going on here (physics question)… although I am satisfied with my math, I think it is not enough to help me with physics…"

- Is the knowledg
  enough for phys
  - Yes (7 of 8)
  - No (1 of 8)

Results: Phase I (2 of 2)

- Lack of confidence in setting-up physics problems

Role of

- Added questio
  possible to set
  - Yes (2 of 5)
  - Do not know (1 of 5)
  - No (2 of 5)

"I am not confident if I set up the problem right or wrong…" "so many numbers and constants to taking account, I get confused, I lose objective of what I am actually looking for… " "as soon as I set it up, there is no problem"

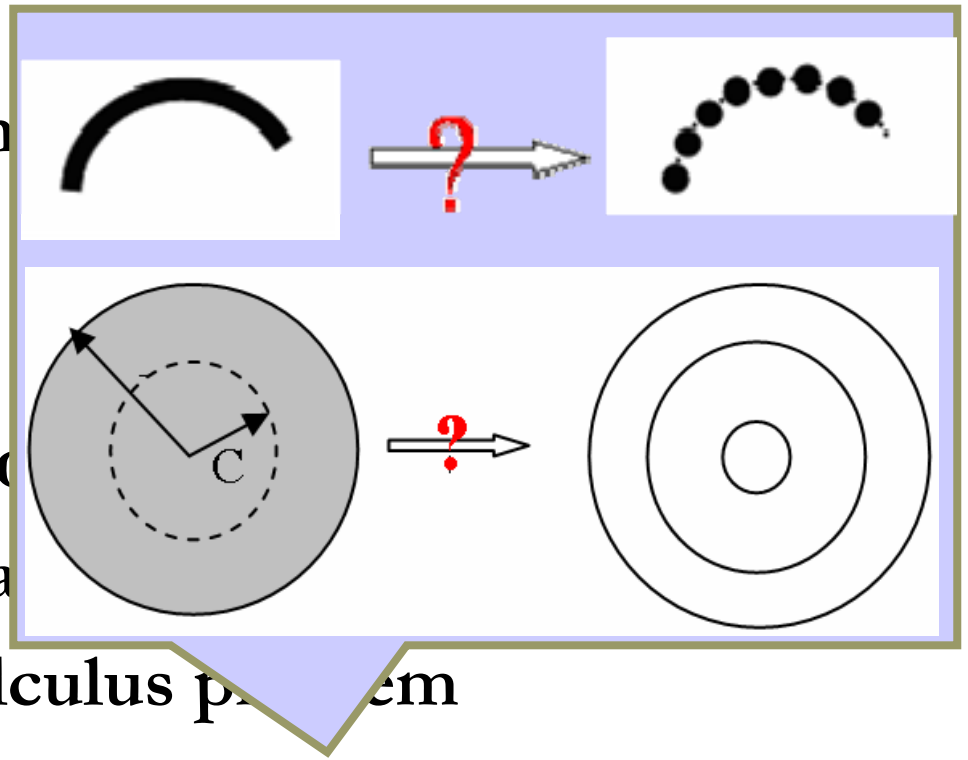
calculation. So set it up is usually a physics thing. You can still understand qualitatively…"

"formula are all involved calculus, if I do not know, I will not understand the meaning of physics at all…"

-reflections are consistent with our observations.

Phase II: Spring 2005
Individual Think Aloud Interview

- **Participants**
  - Five males, three fem
  - Various majors
- **For each session (two**
  - Similar format as Pha
  - Do not solve pure calculus p em
  - Contrast use of "integration" vs. "summation"



Focus on exploring the origin of difficulties

Results: Phase II

- Consistent with results

"Because it is the example in the book… I do not know the reason"; "I just know there is integral involved, I do not know why"

- When to use integration in physics problems
  - When problems were similar to the examples they had seen in the text (4 out of 7 interviewees)
    - Could not explain why use integ
    - Could not solve the contrasting

"...you can not add up an infinite number…then I used integrate"

  - Use integration in terms of adding up the infinitesimally small elements (3 out of 7 interviewees)

Results: Phase II (2 of 4)

- Difficulties when applying integrals
  - Determining the variable of integration
  - Deciding the limits
    - Students usually dic
      limits
  - Origin of difficulti
    - Physics class (maj
    - Calculus class

"I know how to integrate it, but it is just figuring out what to integrate, that is the hard part…"

"These are all constants, I do not

"…not really to do with my math class…. I know how to integrate it, but it is just figuring out what to integrate, that is the hard part"

understand them well. …well, it is not physics is that hard, math is that hard, it is putting them together is hard, it is writing a equation for what I understanding is hard."

Results: Phase II (3 of 4)

- Students prefer to use pre-derived algebraic relationship over calculus relationship
  - unaware of when to use integration

$$B = \frac{\mu_0 i}{2\pi r} \quad \text{or} \quad \oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enclosed}$$

- Is use of calculus in phys… chug"?
  - Yes (6 of 8)
  - No (2 of 8)

"more confidently use algebra expression to go straight rather than …ulus)"

"I do not need to understand it, just how to do it. And I was doing good this way in calculus"

" I have to understand or I will be confused"

Results: Phase II (4 of 4)

- Students suggestions:
  - Learning how to set-up physics problems
  - Focus on understanding
  - More 'word' problems in
  - Course sequ

"I do not think they need to go through all the

"even in calculus, I had to understand why the differentiation of s^2 equal to 2s…"; "why integration and differentiation works."

"…in word about what they can do that in calculus, that would be helpful, so when you go to physics, you are learning new material, like electricity, but you already know calculus."

Conclusions (1 of 2)

Q1: To what extent do students retain and transfer their calculus knowledge while solving problem in introductory physics?

Students believed that they…

- Retained their calculus knowledge well
- Were able to transfer their knowledge from calculus to physics

Q2: What difficulties pertaining to the transfer of calculus do students have while problem solving?

- Determining whether calculus is applicable in a given physics problem
- Deciding the appropriate variable and limits of integration
- Using oversimplified algebraic relationships to avoid using calculus

Conclusions (2 of 2)

Q3: What strategies may help students overcome these difficulties?

- Better scaffolding to help solve physics problems
- Focus on conceptual understanding
- More application-oriented problems in their calculus course
- More careful attention to course sequencing

Future Plans

- Develop instructional strategies to facilitate students' transfer from calculus to physics.

- Investigate transfer across other domains e.g.,
  - Physics to Engineering
  - Other disciplines

Are issues similar or different?

Thank You!

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