Assessing College Students’Retention and Transferfrom Calculusto Physics

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

Work supported in part by NSF grant DUE-0206943

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

1Byrnes (1996) 2Newmann (1989)

Quantitative Method: Examine Students’ Exam Performance

- Engineering Physics II students
  - n=147 for Fall 2004, n=269 for Spring 2005
  - Three exams were collected for each semester

- Develop individual rubric to measure physics correct and calculus correct in every calculus-based physics problem

- Calculate the Pearson Correlation between students’ calculus and physics performance

Example—Scoring Rubric

<table>
<thead>
<tr>
<th>Points</th>
<th>Physics Performance Criteria</th>
<th>Calculus Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Understand need to integrate from infinity to R with the proper E</td>
<td>Do the integration correctly, knowing how to apply the limit</td>
</tr>
<tr>
<td>2</td>
<td>Do the integral with the proper E, but do not know what is the limit; wrong with the negative sign, did not put the number in finally</td>
<td>Do the indefinite integration correctly, do not know how to apply limit; algebra wrong: do not provide the numerical answer</td>
</tr>
<tr>
<td>1</td>
<td>No integral, Use other formula like V=Ed or put into the wrong E; or adding two parts</td>
<td>The indefinite integration is not exactly right, some constant is wrong</td>
</tr>
<tr>
<td>0</td>
<td>Wrong: Like Use a point charge formula instead of using E</td>
<td>Wrong</td>
</tr>
</tbody>
</table>
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

Focus on exploring the origin of difficulties

Interview 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.

Quantitative Results

<table>
<thead>
<tr>
<th>Parameter Correlation between Calculus and Physics Performance</th>
<th>Fall 2004 (p&lt;0.05)</th>
<th>Spring 2005 (p&lt;0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>Math in part (x)</td>
<td>Physics in part (x)</td>
</tr>
<tr>
<td>Fall 2004</td>
<td>0.12</td>
<td>0.66</td>
</tr>
<tr>
<td>Fall 2004</td>
<td>0.38</td>
<td>0.64</td>
</tr>
<tr>
<td>Final Exam</td>
<td>0.50</td>
<td>0.64</td>
</tr>
<tr>
<td>Spring 2005</td>
<td>0.66</td>
<td>0.94</td>
</tr>
<tr>
<td>Spring 2005</td>
<td>0.88</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Strong correlations between math and physics performance ➔ Possibility of transfer from calculus to physics

Interview Results: Spring 2005

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

Interview 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
Conclusions

- The strong correlations between students' calculus and physics performance indicates transfer.

- 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.

- Students need external clues to facilitate the transfer process.

Further Work

- Collect participants' scores in their calculus class and conduct correlation analysis.

- Run hierarchical cluster analysis using all kinds of variables to find how they relate to each other.

For More Information...

Lili Cui
Kansas State University

lili@phys.ksu.edu
(785)532-7167