Parachute Courses: Reducing DFW Rates in Introductory Calculus-based Physics

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General Physics 1 is a Killer Course  
with or without calculus DFW rates of 20-60%

Why?

- Course covers an enormous amount of material – often better than a chapter a week
- Assumes a good understanding of math prerequisites – Algebra, Trigonometry and often Calculus
- Many concepts are counter-intuitive
- Students learning new thinking and math skills as well as new content
- Often hard to visualize what is going on
- Course structure based on premise that students had physics in high school
Defining the problem

* If we want more students to earn STEM degrees, we need introductory physics to be more of a pump, than a filter.

* How do we keep more students in the STEM pipeline with an introductory physics sequence that assumes students have a good background from prior math and physics classes?

* How do we improve student learning outcomes and passing rates?
Defining the problem further:

Two key needs

* Without changing the course, how do we bring students who fail General Physics 1 to where they need to be, so they can be successful when they retake it.

* How do we keep students from failing the first time so they don’t risk losing scholarships/financial aid (reduced credits, lower GPA).
Background

• Southwestern urban university
  less <10% of students living on campus

• Academic rating = 180\textsuperscript{th} tied
  (US News & World Report 2016 Best Colleges)
  Engineering College ranked 14th nationally (Princeton Review)

• Enrollment = 27,000 students (20,000 undergraduates)

• Student average age = 24
  large fraction of 1\textsuperscript{st} generation college students
Background

• Student Population:  
  40% Hispanic / 5% Native American

• Many students on scholarship; most provided by state lottery scholarship program

• Six year graduation rate is 47%

• Freshman retention rate is 77%
General Physics 1

- Course is primarily for engineering majors / some physics majors
- 3 credit 3 hours/week lecture in 275-student lecture hall with excellent demonstration facility attached
- Optional 1 hour/week problem solving (discussion) section taught by lead instructor – taken by 10-40% of students
- Optional (required by some majors) separate 1 credit 3 hour/week lab
- DFW (failure to pass with a C or better) rate of 40-70%
Solution = A Parachute Course

Make it a parachute course:

• A course that students can switch into mid-semester (2\textsuperscript{nd} half-semester course), giving them a 2\textsuperscript{nd} chance in General Physics 1 and preventing them from failing

• Help students build the skills and knowledge they need to be successful in General Physics 1
Solution = A Parachute Course

- More intense, Four 75 minute meetings per week
- Uses integrated lecture/lab with activity-based learning
- Have it meet before 9 AM => minimal interference with other classes (or after 6 PM)
Course Format

- Physics 110 meets MTuWTh from 7:30-8:45 AM in a lab or studio classroom

- Students sign form to switch into the Parachute Course; Register processes form manually to remove General Physics 1 from student transcript and add Parachute Course

- No cost to students for switching; Instructor switches students online homework & e-textbook that emphasizes conceptual understanding, visualizations, & problem solving

- Until recently, some students take Parachute Course as physics prep class to prepare for General Physics 1 (more later)
Course Format

- Curriculum is adopted from award-winning high school curriculum => ASU Modeling Instruction with extra material on problem solving, vector analysis, & symbolic algebra
- Mostly learning by doing, minimal lecturing
- Each activity ends with student group(s) presenting work to class - followed by class Q and A discussion
- Course pace slower with less homework than General Physics 1
- Students can pass with a C with good effort, but students told B or better is needed to succeed when retaking General Physics 1
Typical Unit

• Starts with visualization diagrams and/or graphs from observations and experiments

• Key Ideas & Equations are derived from experiments & observations

• Students summarize each activity on a whiteboard

• End of each activity is a white board Q & A session => board meeting - groups get up and present activity results
Typical Unit (cont.)

• Problem worksheets assigned to **practice applying concepts**

• Students **work in groups** on worksheets in class and present/discuss results in class before submitting as homework

• Sometimes **follow-up experiments** are used to modify/deepen the model

• General Physics 1 **HW problems assigned in Mastering Physics**
Emphasis on Good PS Practice in class

- Students are taught an expert problem solving strategy SPS – Strategic Problem Solving
- Start by visualizing the problem with diagrams and graphs
- Then identify the key concept(s)
- Working problems step-by-step on paper
- Every calculation is preceded by solving for the unknown in symbols => all algebra done in symbols
- Course material is centered on building, understanding, and applying essential force & motion models
Sample Whiteboards
Does it work?

Two criteria

1. Helping struggling students in General Physics 1 not fail and maintain their semester credits and their GPA

2. Helping students develop knowledge and skills needed to pass General Physics 1 course when they retake it
Criteria 1

1. Helping struggling students in General Physics 1 not fail and maintain their semester credits and their GPA
   • 79% of students taking the parachute class passed with at least a C.
2. Helping students develop knowledge and skills needed to pass General Physics 1 course when they retake it

- This was trickier. Coulombe did a longitudinal study of students who retook General Physics 1
  - 105 students took the parachute course before retaking
  - 180 students retook the course without taking parachute course
2. Helping students develop knowledge and skills needed to pass General Physics 1 course when they retake it

- Coulombe did a longitudinal study of students who retook General Physics 1
- Letter grades converted to 12 point numeric scale
- Ran linear regression analysis using R (Lavaan equation modeling package) of several factors including student GPA and SAT/ACT.
Criteria 2 Results

2. Helping students develop knowledge and needed to pass General Physics 1 (GP1) course when they retake it

- Although students who did not take the parachute course has a slightly lower mean grade when retaking GP1 (C vs. C+, p < 0.447, not statistically significant)

- Students who passed parachute class with a grade lower than B had lower mean grade when retaking GP1 than students who passed with a B or better (C- vs. C+/B-, p < 0.001, is statistically significant)
2. Helping students develop knowledge and skills needed to pass General Physics 1 (GP1) course when they retake it

- Students who passed parachute course with B or better had a higher mean grade when retaking GP1 than students who retook GP1 without taking the parachute course (C+/B- vs. C/C+, p < 0.01, is statistically significant)

- However, when students’ GPA taken into account, this last result is no longer statistically significant (p < 0.716)

- Student GPA correlated strongly with grade in GP1 in general (Wald z = 12.58 p < 0.001)
Criteria 2 Results

• Students who passed parachute course with B or better had a higher mean grade when retaking GP1 than students who retook GP1 without taking the parachute course (C+/B- vs. C/C+, p < 0.01, is statistically significant)

• However, when students’ GPA taken into account, this last result is no longer statistically significant (p < 0.716)

This result suggests that of the students switching or dropping GP1, the students with higher GPA (better students?) are taking the parachute course.
Result Summary

• The current Parachute Course does a good job of improving student retention by helping students maintain their GPA (79% success rate).

• For students in the Parachute Course, achieving a “B” or better helps students succeed when retaking General Physics 1.

• Although at first glance, it looks like the Parachute Course helped students achieving a “B” or better in that course performed better in General Physics 1, the difference closes to statistical insignificance when students’ general GPA is taken into account.
Discussion

• Further study is needed to determine whether the Parachute Course helps students succeed when retaking General Physics 1
  • If not, then a redesign to make the course more effective or other options should be considered

• A similar course at University of Illinois has changed to a full semester prep class that students can switch into from General Physics 1 during the add/drop period (Gary Gladding).

• At this school, a one-semester prep class has been implemented in parallel with the parachute course. The students who previously took the parachute course as a prep course not take this class.
Thought for the day: A good engineer is one who has made the right mistakes and learned from them

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