CSU STEM Student Success: Focus on Physics

Monika Kress
Dept. of Physics & Astronomy
San Jose State University
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Outline

• How physics fits into STEM curriculum
• Interesting data from 105 students who took physics with me in Spring 2009
• Results from our prep course
• Problems encountered by students and faculty in physics
• Solutions we have implemented at SJSU
Calculus-based Physics

• 2-3 courses for engineering & physical sciences (EPS) – not for bio, health, aviation, ...
• SJSU: Physics 50,51,52
  • 50 : classical mechanics (pre-req Calc 1)
  • 51 : electricity & magnetism (pre-req 50 and Calc 2)
  • 52: Thermo, optics, modern physics (pre-req 51)
• Physics 50/51/52 are pre-reqs for most STEM curricula (except CS and math)
• I do not curve – must achieve certain level of problem solving skills to get A/B/C, ...
What makes EPS different from other degrees?

• Require math beyond Calc 1 (Calc 1,2,3; often Diff eq, Linear algebra)
• Strict pre-req pathway to the degree (after 50, 6 semesters to degree)
• The major/support courses require quantitative reasoning using trigonometry and calculus
• Calc-based physics appears EARLY in the 4-year plan (w/in 30 units)
• “studying” for STEM is not the same as studying for GE
Our students are not all the same, why should the solution be targeted at everyone?

• Flipped classrooms and iPads are nice, but alone they cannot fix the “outside the classroom” issues that students face

• Classroom solutions will benefit the best students most
Typical physics 50 problem:

A skier glides straight down a slope that has an angle of 7.00° relative to horizontal. The coefficient of kinetic friction between the skis and the slope is 0.100. The skier begins with a speed of 4.00 m/s.

What is the skier’s speed after 10.5 seconds?

To solve this requires reading comprehension and using your conceptual knowledge of physics, but also you must do a lot of things you normally do not do in other classes:

• Draw quantitative, mathematical diagrams that show inter-relationships between relevant quantities (many of which are not identified in problem or asked to be solved for)
• Set up a set of quantitative relationships between all of those quantities

To become good at things you don’t normally do, you must read and watch and listen and write, but you also must practice.
Example of work from an A student:

1) Translation of words into a mathematical diagram

2) Identifying the relevant quantities, both given and unknown

3) Setting up the algebraic relationship between the quantities

4) Numerically solving the problem

A skier glides straight down a slope that has an angle of 19° relative to horizontal. The coefficient of kinetic friction between the skis and the slope is 0.200. The skier begins with a speed of 6.00 m/s.

What is the skier's speed after 9.50 seconds?
Example of work from a D/F student (who is known to be “trying hard”):

1) Instead of a mathematical diagram, he draws an overly simplistic sketch of the scenario.

2) He identifies the given quantities but does not identify the ones that are not given.

3) He can identify some equations that are relevant but does not know how to apply them.

A skier glides straight down a slope that has an angle of 7.00° relative to horizontal. The coefficient of kinetic friction between the skis and the slope is 0.100. The skier begins with a speed of 4.00 m/s.

What is the skier’s speed after 10.5 seconds?
Why do (motivated & able) students fail?

• They cannot solve quantitative problems. Why?
• They do not have sufficient quantitative problem-solving skills. Why?
• Their study time and/or activities were insufficient. Why?
  – They do not have a life structure that allows them access to space, quiet, study pals, etc
  – Financial pressures: They register for too many classes (“I need 12 units for financial aid”) = spread too thin
• They don’t know what studying in STEM means
  – “I read the book, come to class, do my homework, why am I failing?”
• They see their classes as boxes to check
Physics 50 is a microcosm of STEM degrees

• In 50 & 51: D/F rate of 35-40% (no curve)
• Strong correlation with success in 50 and graduating STEM: warrants a closer look at what happens before/during 50
• 4 year plan calls for 50 within 30 units
• In reality, 50 is taken at 65 units (~4th semester)
• Bimodal distribution of grades (a peak ~ B and a broad distribution at low end)
### Physics 50 Spring 2009

<table>
<thead>
<tr>
<th>Everyone</th>
<th>Non-remedial/transfer</th>
<th>Started SJSU remedial</th>
</tr>
</thead>
<tbody>
<tr>
<td>105 (2 W’s)</td>
<td>75 (71%)</td>
<td>30 (29%)</td>
</tr>
<tr>
<td>A (10%)</td>
<td>10 (13%)</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>B (33%)</td>
<td>29 (39%)</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>C (21%)</td>
<td>16 (21%)</td>
<td>6 (20%)</td>
</tr>
<tr>
<td>D (11%)</td>
<td>8 (11%)</td>
<td>4 (13%)</td>
</tr>
<tr>
<td>F (21%)</td>
<td>11 (15%)</td>
<td>11 (37%)</td>
</tr>
<tr>
<td>Average</td>
<td>2.4</td>
<td>1.6</td>
</tr>
</tbody>
</table>
### Graduating vs. grade in 50

<table>
<thead>
<tr>
<th>Everyone</th>
<th>STEM degree</th>
<th>Non-STEM degree</th>
<th>Dropped out</th>
<th>DQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>105 (2 W’s)</td>
<td>59*</td>
<td>5</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>A (11)</td>
<td>10</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>B (36)</td>
<td>23+1ip</td>
<td>10</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>C (22)</td>
<td>10+1ip</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>D (12)</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>F (22) (avi,CS,bio)</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

* 2 still working on it
# How long did it take to graduate STEM?

<table>
<thead>
<tr>
<th>Degree received</th>
<th>Non-remedial/transfer</th>
<th>Started SJSU remedial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2011 (4 sem after 50)</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Fall 2011</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Spring 2012</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Fall 2012</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Fall 2013</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Fall 2014 (11 sem after 50)</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Average: Fall12/Spr13, Fall12/Spr13
Grade vs time to graduation

<table>
<thead>
<tr>
<th>Grade</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spr 11 (4 sem after 50)</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fall 11</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spr 12</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Fall 12</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Spr 13</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Fall 13</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Spr 14</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fall 14 (11 sem after 50)</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>average</td>
<td>7.4</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>(7???)</td>
</tr>
</tbody>
</table>
## Where are they now?

<table>
<thead>
<tr>
<th>Everyone</th>
<th>Non-remedial/transfer</th>
<th>Started SJSU remedial</th>
</tr>
</thead>
<tbody>
<tr>
<td>105 (2 W’s)</td>
<td>75 (71%)</td>
<td>30 (29%)</td>
</tr>
<tr>
<td>Graduated STEM (incl. bio, biochem, forsci)</td>
<td>39 (52%)</td>
<td>14 (47%)</td>
</tr>
<tr>
<td>Graduated tech/avi</td>
<td>2 (3%)</td>
<td>2 (7%)</td>
</tr>
<tr>
<td>Still working toward STEM degree</td>
<td>1* (1%)</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Graduated non-STEM</td>
<td>4 (5%)</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Did not graduate, But not DQ</td>
<td>17 (23%)</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>DQ</td>
<td>9 (12%)</td>
<td>5 (17%)</td>
</tr>
</tbody>
</table>
Summary of data

• Former remedials are under-represented among A’s and over-represented among F’s in physics
• Getting a STEM degree strongly correlates with grade in physics
• Remedials get STEM degrees in same proportions as non-remedials!
• Remedial C’s are more likely to get STEM degree than non-remedial C’s!
• A students get degree 1.5 semesters sooner than B/C/D students. Few actually get degree within 6 semesters (usually bio, avi, tech)
Problems, from my perspective

• GPA (even major GPA) is poor measure of progress to degree – those who struggle are not identified early enough
• No substitute for looking at individual transcripts!
• Prep courses are at odd with 4-year plan, graduation rate
• Students lack access to out-of-class support structure (time, study groups, quiet safe study spaces)
• Students have not enough or too many advisers, inexperienced advisers
  – No supervision of what classes they register for
  – No appreciation of pre-req pathway
• Students are unaware that succeeding in STEM is NOT the same as succeeding in GE (go to class, read book, do homework, get A)
  – “studying” for STEM = practice!!
• Come in with huge # of units, fails classes, get DQ’d, get discouraged, leave with no degree
• We can’t iPad our way our of this.
Physics 49: Prep class for 50

• First offered in Fall 2013
• Targeted toward students at risk of not succeeding in 50:
  – remedial (English or math)
  – previous D/F in any class (usually math/chem)
• Goal is to prepare them for 50
• “on the fence” students have an opportunity to assess their choice of major
Results: Physics 49 Fall 2013

• 44 students enrolled (>400 in Physics 50)
• Instructor: Outstanding lecturer for 2014, Olenka Hubickyj
• 18 were transfer students
• 33 were “at risk” (remedial and/or previous D/F)
• 4 remedial math are no longer STEM majors:
  – All 4 were also remedial in English
  – 3 are making progress to non-STEM major, #4 is no longer enrolled but was not dq

• Defining characteristic of the class was transfer vs. native SJSU:
  – 9/18 transfer students went on into Physics 50, they had an average grade of 3.03 in 49 and got an average grade of 3.08 in 50 (avgΔ=+0.04)
  – 12/26 of SJSU students went on into 50, their average grade in 49 was only 2.25 and they got an average grade of 1.7 in 50 (avgΔ=-0.5)
Changes I made to Physics 50

• We went from 8-10 “small” sections (40-45) to 2 large sections of 200
• Removed low-performing instructors in place of tenured faculty w/excellent teaching evals
• Enforce pre-req – I check all transcripts
• Make sure they are declared in the major or at least seeing a STEM adviser (no ‘ghosts’ or undeclared)
• Labs involve weekly “proficiency quizzes” on core topics – students must pass each before progressing to next
• Labs also involve much more problem solving time
• Lab & workshop instructors must complete 1-day training
Results (working on it)

- D/F rate hasn’t budged, BUT transcript data show good correlation with grade in statics and Phys 51, 52 (not true before)

From Carel Boekema: “The Phys50 students who took the 200-size classes have a median of a B+ in the grade distribution (w/ peaks @ B & A+) while the Phys50 students who took the <50-size classes had a median of C+ (w/ peaks @ C & B-).

<table>
<thead>
<tr>
<th>Size 50Class</th>
<th>%A</th>
<th>%B</th>
<th>%C</th>
<th>%D/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>'200'</td>
<td>39</td>
<td>40</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>'50'</td>
<td>11</td>
<td>39</td>
<td>26</td>
<td>24</td>
</tr>
</tbody>
</table>

This anecdotal evidence indicates the Phys50 major changes (including Phys49) make quite a difference!
Future Solutions

• Align faculty success with student success: we need TIME and acknowledgement for RTP!
• Get units for study hall????
• Adequate compensation for student assistants who tutor STEM!!
• More engagement in small class settings (labs and workshops)
• Build strong study communities
• Places to have study sessions
• solutions targeted toward “everyone” will help those who already are ok
• Check transcripts to determine who needs help/ intervention
Who needs help?

- GPA – even major GPA – is a poor metric to determine who needs help
- Better metric is whether student actually gets D or F in lower division STEM
We need to define “success”

• Greater # of STEM graduates?
• Higher fraction graduating, but maybe fewer in #?
• Shorter time to graduation, but fewer in #?
• Smaller fraction failing out of university?
• Re-directing out of STEM sooner?
Resources for aspiring STEM students:

- “So good they can’t ignore you,” Cal Newport
- “Mindset: The new psychology of success,” by Carol Dweck
- Videos by Dr. Stephen Chew at Samford University: http://www.samford.edu/departments/academic-success-center/how-to-study/