“Algebra-based introductory Physics 1 in a flipped classroom format”

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Department of Physics and Astronomy

Final Report to dB-SERC, May 16, 2016
Outline

• About Intro to Physics 1
• Workflow of flipped classroom
• Enrollment and framing
• Examples from class
• Conceptual gains
• Attitude shifts
“Intro to Physics 1” audience

Physics 0110 is the first term of a two-term sequence which presents the elements of both classical and modern physics. The emphasis of this fast-paced course is on a clear understanding of the underlying principles [...]. This course is intended for non-science majors, and for those majoring in the social, psychological and life sciences. [...]

“Intro to Physics 1” demographics

Fall 2015 Traditional, N= 207

- Freshman: 10%
- Sophomore: 43%
- Junior: 36%
- Senior: 12%

Spring 2016 Flipped, N= 238

- Freshman: 16%
- Sophomore: 45%
- Junior: 31%
- Senior: 9%

Percentages based on grade roster (after add/drop period)
Workflow (12-day cycle)

- Watch (5-10 min) **videos** (total < 1 hr), answer online **multi-choice checkpoints**
- **Practice + get feedback** (peers+coach)
- Solve a **context-rich problem** in group*
- Do online **homework** (∼80% of trad’s)
- Take in-class learning assessment **Once a month**
What did I do \textbf{differently}? 

- \textit{Restructure} lesson plan into small units
- \textit{Expand} range of classroom activities
- \textit{Train} undergrad teaching assistants
- Hear students in \textit{focus groups} (Week 6)
What did I do as usual?

• *Present concepts in real-life scenarios*
• *Use cooperative learning* in recitations
• Encourage peer interactions in class
• *Post all course material on Courseweb*
Signup for Fall 2015 pilot flipped section

In Fall 2015, course description said “taught in a hybrid format”. (Students signed up for only 1.3 hours a week*) Students did not know actual format until Day 1.

Notes:
Selection bias: limited contact hours; evening class (6pm), taking more nontraditional students.

Several students seriously underestimated amount of work necessary, based on sole fact that in-class time was half of usual. (source: focus groups)
Signup for Spring 2016 flipped section

In Spring 2016, course description should have clearly explained format yet was not updated by University. (Students signed up for 2.5 hours a week.*) Students had no idea course would be taught in a nontraditional format. *I told them on Day 1.*

Notes:
No selection bias.

Several students felt “stuck” in section and endured flipped format for lack of alternatives (source: focus groups, OMET survey)
FW rates

Fall 2015 *Traditional, N = 207*

*W = 4 (1.9%), F = 3* (1.5% of A-F grades)*

*Pilot Flipped: N=80; W = 5 (6.3%), F= 3** (3.8%)*

Spring 2016 *Flipped: N = 238*

*W = 13 (5.6%), F = 3*** (1.3 % of A-F grades)*

*None took Final Exam.*

**Only one took Final Exam. Other two took two midterms.*

***None took Final Exam (one “ghost” in class roster).
Why should this format work?

- **Learning is active**: *you can only learn by doing, not by watching others do.*

- **Coaching by an expert** is a key resource for learners.

- **Collective engagement** can make in-class periods more enjoyable. 😊😊😊
Benefits of flipped classroom format

Outside of classroom, you

• may *replay, pause, rewind, forward* lectures.
• easily avoid issues of “cognitive overload”.
• learn material at your own pace.

In the classroom, you

• engage in *active learning* almost *all the time*.
• receive immediate *feedback from the instructor*.
• more frequently *interact with your classmates*. 

As shown to students Day 1
Example of video module

**Module 2** (linear kinematics)

2.1 *Displacement*, 4:40
2.2 *Speed and velocity*, 9:25
2.3 *Acceleration*, 4:44
2.4.a *Constant Acceleration Part 1*, 6:57
2.4.b *Constant Acceleration Part 2*, 7:47
2.4.c *Constant Acceleration Part 3*, 6:02
2.5.a *Free fall Part 1*, 9:07
2.5.b *Free fall Part 2*, 8:16

(2.SP Sample Problems, 13:29)
Example of video view statistics

Stats for PHYS 0110 flipped

Minutes viewed data current as of: 4/22/2016 11:22:46 PM (Eastern Daylight Time)
Example of video checkpoint

Question

Which of these statements regarding *velocity* is true?

a) Velocity tells the instantaneous direction of motion.
b) Velocity has the same meaning speed has.
c) Velocity is a scalar quantity just as distance.
d) Velocity depends on the chosen origin of coordinates.
e) Velocity simply answers the question “How fast?”.
A train is moving along a piece of straight track oriented in the $+x$ direction, and the graph below is supposed to represent the motion of that train. What is the graph telling you?

a) The track is actually uphill.
b) The train is speeding up.
c) The train is slowing down.
d) The train moves at constant pace.
e) The train is moving backward.
Example of in-class pair activity

You can run as fast as 10 m/s. A lion can run as fast as 22 m/s. A healthy lion has just escaped from the local zoo, and is 270 m from you. It starts running toward you, and you run away immediately. (You both ran at your fastest.) How far from you should a shelter be (at most) for you to save your skin?

\[
x(t) = x_0 - vt
\]

\[
x_h = x_0 + v_h t^*
\]

\[
x_e = x_0 + v_e t^*
\]

\[
v_h = 10 \text{ m/s} \quad h: \text{ human}
\]

\[
v_e = 22 \text{ m/s} \quad e: \text{ lion}
\]

\[
\frac{D - x_0}{D} = \frac{v_e}{v_h} \Rightarrow 1 - \frac{x_0}{D} = \frac{v_e}{v_h} \Rightarrow 1 - \frac{v_e}{v_h} = \frac{x_0}{D} \Rightarrow
\]

\[
D = \frac{x_0}{1 - \frac{v_e}{v_h}} = \frac{-270 \text{ m}}{1.2} = \frac{270 \text{ m}}{1.2} = 225 \text{ m}.
\]

Me hungry.
Course transformation goals

Objective indicators

- **Gain in conceptual understanding**
- **Exam scores** (*midterms*, final exam***)

Subjective indicators

- “Overall, did you **enjoy** the flipped classroom format?”
- “If you had the chance, would you take another course in flipped format?”
Pre- and post- FCI scores (pilot)

$p = 0.3867$

$p = 0.0508$
Normalized learning gains (pilot)

\[ \langle g \rangle = 27.0\% \quad (n=55) \]

\[ \langle g \rangle = 22.5\% \quad (n=169) \]

\[ p = 0.1481 \]
Midterm exams performance (pilot)

Exam 1, Flipped

Exam 2, Flipped

Exam 3, Flipped

Exam 1, Traditional

Exam 2, Traditional

Exam 3, Traditional

$p = 0.0163$

$r = 0.1069$

$p = 0.2012$

$p = 0.2997$
Final exam* performance (pilot)

*Two groups were given identical exams

\[ p = 0.4629 \]

\[ \langle s \rangle = 54.85\% \]

\[ \langle s \rangle = 54.60\% \]
Pre-instruction conceptual scores (FCI)

\[ p = 0.3992 \]
Post-instruction conceptual scores (FCI)

Spring 2016

\[ <Post> = 54.6\% \quad (n=195) \]

Fall 2015

\[ <Post> = 48.8\% \quad (n=169) \]

\[ p = 0.0027 \quad r = 0.1459 \]
Pre- and post- conceptual scores (FCI)

$p = 0.3992$

$p = 0.0027$
Normalized learning gains (FCI)

Normalized Gain on FCI, Flipped

\[ \langle g \rangle = 30.7\% \quad (n=195) \]

Max \( g = 93\% \)

Normalized Gain on FCI, Traditional

\[ \langle g \rangle = 22.5\% \quad (n=169) \]

Max \( g = 75\% \)

\[ p = 0.00071 \quad r = 0.1459 \]
Final exam* performance (Spring2016)

Two groups were given isomorphic exams

\[ \langle s \rangle = 58.66\% \]

\[ \langle s \rangle = 54.60\% \]

\[ p = 0.0070 \quad r = 0.1202 \]
Correlation: post-instruction conceptual survey and final exam performance

Spring 2016

$\text{PHYS 0110 Flipped (Spring 2016)}$

- Final Exam score vs. Post-instruction FCI score

$\text{Final Exam score}$

$\text{Post-instruction FCI score}$

$\text{Spring 2016}$

$r = 0.5631$

Fall 2015

$\text{PHYS 0110 Traditional (Fall 2015)}$

- Final Exam score vs. Post-instruction FCI score

$\text{Final Exam score}$

$\text{Post-instruction FCI score}$

$\text{Fall 2015}$

$r = 0.5505$
"Personal enjoyment" (survey)

"Overall, I think I enjoyed the flipped format."

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>10.22%</td>
</tr>
<tr>
<td>Agree</td>
<td>33.33%</td>
</tr>
<tr>
<td>Disagree</td>
<td>23.12%</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>14.52%</td>
</tr>
<tr>
<td>Neutral</td>
<td>18.82%</td>
</tr>
</tbody>
</table>

n=186 (82% of grade roster)
“Repeatability” (survey)

“If I have the chance, I think I will take another course taught in the flipped format. (Think of any other course relevant to your major.)”

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<td>11.83%</td>
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<tr>
<td>Agree</td>
<td>25.81%</td>
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<tr>
<td>Disagree</td>
<td>19.89%</td>
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<tr>
<td>Strongly Disagree</td>
<td>21.51%</td>
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<tr>
<td>Neutral</td>
<td>20.97%</td>
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n=186 (82% of grade roster)
**Broader relevance (survey)**

Question: "*Learning physics helps me understand situations in my everyday life.*"

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<thead>
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<th>Post</th>
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<tr>
<td>Agree</td>
<td>81%</td>
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<td>Disagree</td>
<td>19%</td>
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Flipped, Spring2016

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<tr>
<td>Agree</td>
<td>91%</td>
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Traditional, Fall2015 (subset*)

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Q: "*Knowing physics helps me understand how the world works.*"

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N=145* (64% response rate)

N=79 (39% response rate)
Epistemological beliefs (survey)

Q: "Knowledge in physics consists of many pieces of information each of which applies primarily to a specific situation."

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<td>57%</td>
<td>66%</td>
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<td>Disagree</td>
<td>43%</td>
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Traditional, Fall 2015 (subset*)

N=145* (64% response rate)

N=79 (39% response rate)

Q: "Learning physics is mainly about remembering the laws, principles, and equations given in class and/or in the textbook."

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