Creating the ultimate flipped classroom: A step-by-step guide for Peer Instruction
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Symposium on Excellence in Teaching and Learning
National Taiwan University
Taipei, Taiwan, 28 June 2016
an illusion...
1. transfer of information
1. transfer of information
2. assimilation of that information
1. transfer of information (in class)

2. assimilation of that information
1. transfer of information (in class)

2. assimilation of that information (out of class)
1. transfer of information (in class)

2. assimilation of that information (out of class)

Should focus on THIS!
1. transfer of information (in class)

2. assimilation of that information (out of class)
1. transfer of information (out of class)

2. assimilation of that information (in class)
1. transfer of information (out of class)

2. assimilation of that information (in class)
question
question

think
question
→
think
→
poll
question

think

poll

discuss
question

think

poll

discuss

repoll
thermal expansion
all of them
Consider a rectangular metal plate with a circular hole in it.
Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.
Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole:

1. increases.
2. stays the same.
3. decreases.

you got all fired up!
Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.
Before I tell you the answer, let's analyze what happened.
Before I tell you the answer, let’s analyze what happened.

You...
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
2. externalized your answer
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
2. externalized your answer
3. moved from the answer/fact to reasoning
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
2. externalized your answer
3. moved from the answer/fact to reasoning
4. became emotionally invested in the learning process
Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.
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1. increases. ✓
2. stays the same.
3. decreases.
consider atoms at rim of hole
consider atoms at rim of hole
consider atoms at rim of hole
consider atoms at rim of hole
consider atoms at rim of hole

you won't forget this
Higher learning gains
Peer instruction

Higher learning gains

Better retention
how to effectively transfer information outside classroom?
but...
• transfer pace set by video
• viewer passive
• viewing/attention tanks as time passes
• isolated/individual experience
we’re simply moving this outside classroom!
• transfer pace set by reader
• viewer active
but...
isolated/individual experience & no real accountability
want:
every student prepared for every class
want:

every student prepared for every class

(without additional instructor effort)
Solution
turn out-of-class component
also into a social interaction!
Perusall every student prepared for every class
In the preceding two chapters, we developed a mathematical framework for describing motion along a straight line. In this chapter, we continue our study of motion by investigating inertia, a property of objects that affects their motion. The experiments we carry out in studying inertia lead us to discover one of the most fundamental laws in physics—conservation of momentum.

4.1 Friction

Picture a block of wood sitting motionless on a smooth wooden surface. If you give the block a shove, it slides some distance but eventually comes to rest. Depending on the smoothness of the block and the smoothness of the wooden surface, this stopping may happen sooner or it may happen later. If the two surfaces in contact are very smooth and slippery, the block will slide very fast. If the surfaces are rough, the block will slide more slowly. You experience this every day. A hockey puck slides easily on ice but not on a rough road.

Figure 4.1 shows how the velocity of a wooden block decreases on three different surfaces. The slowing down is due to friction—the resistance to motion that one surface or object encounters when moving over another. Notice that, during the interval covered by the velocity-versus-time graph, the velocity decrease as the block slides over ice is hardly observable. The block slides easily over ice because there is very little friction between the two surfaces. The effect of friction is to bring two objects to rest with respect to each other—in this case the wooden block and the surface it is sliding on. The less friction there is, the longer it takes for the block to come to rest.

Figure 4.1 Velocity-versus-time graph for a wooden block sliding on three different surfaces. The rougher the surface, the more quickly the velocity decreases.

Figure 4.2 Low-friction track and carts used in the experiments described in this chapter.

You may wonder whether it is possible to make surfaces that have no friction at all, such that an object, once given a shove, continues to glide forever. There is no totally frictionless surface over which objects slide forever, but there are ways to minimize friction. You can, for instance, float an object on a cushion of air. This is not easily accomplished in the laboratory, but it is the principal in a large scale device called the wind tunnel. The wind tunnel serves as a cushion on which a conveniently shaped object can float, with friction between the object and the track all but eliminated. Alternatively, one can use wheeled carts with low-friction bearings on an ordinary track. Figure 4.2 shows low-friction carts you may have encountered in your lab or class. Although there is still some friction both for low-friction tracks and for the track shown in Figure 4.2, this friction is so small that it can be ignored during an experiment. For example, if the track in Figure 4.2 is horizontal, carts move along its length without slowing down appreciably. In other words:

In the absence of friction, objects moving along a horizontal track keep moving without slowing down.

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Figure 4.1 shows how the velocity of a wooden block decreases on three different surfaces. The slowing down is due to friction—the resistance to motion that one surface or object exerts on another when moving over it. Notice how the velocity decreases as the block slides across the different surfaces. The block slides more easily on the low-friction surface because it is not held so tightly to the surface. The block slides less easily on the high-friction surface because it is held tightly to the surface. The less friction there is, the less likely the block is to come to rest.

Figure 4.1. Velocity-versus-time graph for a wooden block sliding on three different surfaces. The rougher the surface, the more quickly the velocity decreases.

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...opens chat window
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action of the force and the axis of rotation. So, the torque caused by a force exerted on an object is the product of the magnitude of the force and its lever arm distance. It can be written equivalently as $rF_1$ and as $rF$.

Like other rotational quantities, torque carries a sign that depends on the choice of direction for increasing $\theta$. In Figure 12.4, for example, the torque caused by $F_1$ about the pivot tends to rotate the rod in the direction of increasing $\theta$ and is positive; the torque caused by $F_2$ is negative. The sum of the two torques about the pivot is then $r_1F_1 + (-r_2F_2)$. As we've seen, the two torques are equal in magnitude when the rod is balanced, and so the sum of the torques is zero. When the sum of the torques is not zero, the rod's rotational acceleration is nonzero, and so its rotational velocity and angular momentum change.

In the situations depicted in Figures 12.4 and 12.5 we used the pivot to calculate the lever arm distances. This is a natural choice because that is the point about which the object under consideration is free to rotate. However, torques also play a role for stationary objects that are suspended or supported at several different points and that are not free to rotate—for example, a plank or bridge supported at either end. To determine what reference point to use in such cases, complete the following exercise.

**Exercise 12.1 Reference point**

Consider again the rod in Figure 12.4. Calculate the sum of the torques about the left end of the rod.

**SOLUTION** I begin by making a sketch of the rod and the three forces exerted on it, showing their points of application on the rod (Figure 12.6).

Exercise 12.1 shows that the sum of the torques about the left end of the rod is zero, just like the sum of the torques about the pivot. You can repeat the calculation for the torques about the right end of the rod or any other point, and each time you will find that the sum of the torques is zero. The reason is that the rod is not rotating about any point, and so the sum of the torques must be zero about any point. In general we can say:

For a stationary object, the sum of the torques is zero.

For a stationary object we can choose any reference point we like to calculate torques. It pays to choose a reference point that simplifies the calculation. As you have seen, we do not need to consider any force that is exerted at the reference point. So, by putting the reference point at the point of application of a force, we can eliminate that force from the calculation.

**12.2** In the situation depicted in Figure 12.2a, you must continue to exert a force on the seesaw to keep the child off the ground. The force you exert causes a torque on the seesaw, and yet the seesaw's rotational acceleration is zero. How can this be if torques cause objects to accelerate rotationally?

**Example 12.2 Torques on lever**

Three forces are exerted on the lever of Figure 12.7. Forces $F_1$ and $F_2$ are equal in magnitude, and the magnitude of $F_3$ is half as great. Force $F_1$ is horizontal, $F_2$ and $F_3$ are vertical, and the lever makes an angle of $45^\circ$ with the horizontal. Do these forces cause the lever to rotate about the pivot? If so, in which direction?
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I don’t understand how this combination of factors tells you anything about direction? Aren’t magnitude and lever arm distance both scalar quantities? It seems like we would need to know some sort of direction to calculate torque.

I think you may be able to think about the direction separately. So, after multiplying this magnitude and distance, you can attach a sign to the torque based on the defined parameters of the system. In the following paragraph, they start to explain how to choose this direction.

This is a great question. To further elaborate on this, we can think of this in terms of the Torque equation. The equation for torque is \( \tau = r \times F \), with \( r \) being the level arm distance and \( F \) being force. We know that force is a vector vector from previous chapters, and in regards to “\( r \)” it can also be thought of as the radial vector. What this means is that this distance from the pivot points from the axis of rotation to the point where the force acts. In as previously mentioned, there is a general convention (the right-hand rule) that is used to determine the direction which happens to be perpendicular to both the radius from the axis and to the force.
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Oct 20 12:09 am

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I don't understand how this combination of factors tells you anything about direction? Aren't magnitude and lever arm distance both scalar quantities? It seems like we would need to know some sort of direction to calculate torque.

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Exercise 12.1 shows that the sum of the torques about the left end of the rod is zero, just like the sum of the torques about the pivot. You can repeat the calculation for the torques about the right end of the rod or any other point, and each time you will find that the sum of the torques is zero. The reason is that the rod is not rotating about any point, and so the sum of the torques must be zero about any point. In general we can say:

For a stationary object, the sum of the torques is zero.

For a stationary object we can choose any reference point we like to calculate torques. It pays to choose a reference point that simplifies the calculation. As you have seen, we do not need to consider any force that is exerted at the reference point. So, by putting the reference point at the point of application of a force, we can eliminate that force from the calculation.

12.2 In the situation depicted in Figure 12.2a, you must continue to exert a force on the seesaw to keep the child off the ground. The force you exert causes a torque on the seesaw, and yet the seesaw's rotational acceleration is zero. How can this be if torques cause objects to accelerate rotationally?

Example 12.2 Torques on lever

Three forces are exerted on the lever of Figure 12.7. Forces \( \vec{F}_1 \) and \( \vec{F}_3 \) are equal in magnitude, and the magnitude of \( \vec{F}_2 \) is half as great. Force \( \vec{F}_1 \) is horizontal, \( \vec{F}_2 \) and \( \vec{F}_3 \) are vertical, and the lever makes an angle of 45\(^\circ\) with the horizontal. Do these forces cause the lever to rotate about the pivot? If so, in which direction?
Brian Lukoff responded to a question in Mazur Chapter 4 Sample that you wanted to know the answer to:

21 minutes ago, you asked this question on Perusall:

No friction at all seems impossible. Isn’t there always some friction in any real case?

Brian Lukoff just responded to the question by saying:

Right - I think there will always be some friction due to the second law of thermodynamics.

If this helps your understanding, click the button below. If you want to respond, simply reply to this email to post to Perusall.

[View conversation] [This comment helps my understanding]
email notifications

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option 1: reply
email notifications

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option 2: view chat

View conversation

This comment helps my understanding
email notifications

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If this helps your understanding, click the button below. If you want to respond, simply reply.

option 3: mark as answered

View conversation

This comment helps my understanding
how to get students to participate?
use combination of intrinsic and extrinsic motivation drivers
rubric-based assessment

- quality (thoughtful reading & interpretation)
rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
- distribution (not clustered)
rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
- distribution (not clustered)

over 20,000 annotations!
rubric-based assessment

• quality (thoughtful reading & interpretation)
• quantity (minimum 10)
• timeliness (before class)
• distribution (not clustered)

how do you process all of that??
rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
- distribution (not clustered)

How do you process all of that??

fully automated assessment
fully automated assessment

- specialized machine learning algorithm
- assesses intellectual content
- exceeds intercoder reliability
### Gradebook

Click on a grade to see details about the student’s assignment.

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<th>Student Name</th>
<th>Student ID</th>
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<th>Chapter 2</th>
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<td>Michael Red</td>
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**Actions:**
- Copy to clipboard
- Download
- Search:
- Release to students
## Gradebook

Click on a grade to see details about the student’s assignment.

<table>
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- **Total number of annotations**: 16
- **Total number of annotations submitted on time**: 11
- **Average quality of top 10 annotations submitted on time**: 1.80
- **Distribution of annotations**: 3.8
- **Assignment score**: 1

scores range from 0 to 3
connect pre-class and in-class activities
Confusion report for Chapter 24

right hand rule (11 questions)
- JB: Can someone in simpler terms explain the right-hand rule?
- WJ: Is there another way, besides the right hand rule, to find the direction of the magnetic field with a current?
- SB: Using the right hand rule, I believe the answer is D. Is that correct?

direction magnetic field (8 questions)
- CP: Why is it that the magnet field points away from the north pole and towards the south pole? When on the previous page it stated that the direction of the magnetic field is the direction that the north pole of a compass needle points.
- AB: How can you determine which direction the magnetic field will point towards?
- KH: So whichever way the north pole faces is the direction of the magnetic field but that doesn't always mean its pointing true north?

earth magnetic field (6 questions)
- CP: Does that mean that the compass will be distracted from the Earth's magnetic field and use the magnetic field that the current of the wire gives off?
- AK: Can someone explain why this type of bacteria knows what direction the earth's magnetic fields are facing?
- J: Does the circular loop of current have any similarities with the look of the earth's magnetic field? They kind of look similar to me.
Motivating factors

Intrinsic:

• Social interaction
motivating factors

Intrinsic:

• social interaction

• tie-in to in-class activity
motivating factors

Intrinsic:
- social interaction
- tie-in to in-class activity

Extrinsic:
- assessment (fully automated)
motivating factors

“I think the Perusall app and annotation system is way better than just reading a textbook normally… I’ve been reading for almost four hours now and haven’t gotten bored”

Harvard student
motivating factors

“It makes the book fun to read...
All the other students on my floor are disappointed their Prof isn’t using Perusall because they don’t read the book.”

Ohio State student
class test results

![Bar chart showing percent of students vs. number of chapters missed before class.]
class test results

close to 95%!
class test results

every student prepared for every class
additional research data

- Engagement: 81% spend 2–6 hrs/wk reading
• Engagement: 81% spend 2–6 hrs/wk reading
• Active reading: 85% annotate as they read and 40% take notes while reading
• **Engagement:** 81% spend 2–6 hrs/wk reading

• **Active reading:** 85% annotate as they read and 40% take notes while reading

• **Performance:** significantly higher scores
Benefits

• virtually 100% completion of assignments
• improved use of class time
Benefits

• virtually 100% completion of assignments
• improved use of class time

all at no cost & without additional instructor effort!
Education is not just about:

- transferring information
- getting students to do what we do
Education is not just about:

- transferring information
- getting students to do what we do

active engagement/social interaction a must!