WHOOPS! I JUST FLIPPED THE CLASSROOM*…

With advocates like Sal Khan (Khan 2011) and Bill Gates, flipped classrooms are attracting an increasing amount of media and research attention (Bergmann 2012). We had heard Khan's TED talk and were aware of the concept of flipped teaching in general. These pedagogies are intriguing and applicable across all disciplines. Yet it really hit home when we accidentally flipped our classroom. Our objective was to better prepare our students for class. We set out to effectively move some of our course content outside of class and decided to tweak the Just-in-Time-Teaching approach (JiTT) (Novak 1999).

To our surprise, this tweak—which we like to call the flip-JiTT—ended up completely flipping our classroom. What follows is narrative of our experience and a procedure that any teacher can use to extend JiTT to a flipped classroom.

OUR ACCIDENTAL EXPERIENCE

Flipping your classroom isn't a trivial change. As experienced physics teachers, we were intrigued but not ready to make major changes. What we were prepared for was another semester of a college course on electricity & magnetism (E&M) using Peer Instruction (Lasry, Mazur, & Watkins 2008a; Crouch & Mazur 2001; Mazur 1997) as developed by Harvard physicist Eric Mazur (Bouffard 2014; Lasry 2008b). We had a few issues we wanted to iron out. In our experience, students spent a fair amount of class time discussing abstract E&M concepts with each other. Using Peer Instruction meant that we had organized our classes around short lectures that were followed by conceptual questions. Students answered these questions individually before discussing them with their peers (Crouch & Mazur 2001). The time spent pairing and sharing in class meant that some topics could no longer be covered in class. Students would have to deal these topics on their own outside of class. As teachers in a multi-section course (we each taught 1 of 10 sections of the course), our students would have to write the same exam as all the other students registered in the course. We had to find a way to get students to be responsible for the material we would no longer cover because of the class time spent in teacher-facilitated peer discussions. In cases like these, Mazur (Mazur 1997) proposed using Just-in-Time-Teaching (JiTT) (Novak 1999).

The JiTT approach is an ideal companion to Peer Instruction because it is a structured approach that helps student prepare for class. In JiTT, reading or other information-gathering activities are assigned *before* a topic is broached in class. Students then complete an online assignment that checks whether they completed the preparation activity and asks what they found difficult or confusing. For instance, students can be given a reading quiz or a couple of conceptual questions to find out if they read carefully. The central feature of JiTT is the feedback question that follows. The standard form of question is a variation on the theme: "what did you find difficult in the readings?" The instructor receives student feedback in the form of responses to this question a number of hours before class (often the night before) and reviews it "just in time" for class. Each class begins with (and can be designed around) what students find difficult. By being exposed to the material before coming to class, students are more deeply engaged in the process of their own learning and are better prepared for an active learning environment. This alleviates some of the time pressure that teachers face in covering content and allows the instructor to focus on making deeper connections between concepts.

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We had tried JiTT in the past with varying levels of success. The main issue was getting students engaged with the material before coming to class. Our experience, albeit anecdotal, was that the students who read were seldom sufficiently engaged in their reading. Our objective for the semester in question was simple: we wanted students to come to class prepared. We set out to create a structure that would make JiTT easier for us to use and harder for students not to use. In using the JiTT approach, we wanted to monitor students' progression before they came to class and find out what they understood and what they had difficulty with. So, we tweaked the standard JiTT approach. What happened took us by surprise: by tweaking JiTT, we accidentally flipped our classroom.

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WHAT ARE FLIPPED CLASSROOMS?

Flipped classrooms invert the conventional way we teach. A simple description[1] is:

> "Flipped Learning occurs when direct instruction is moved from the group teaching space to the individual learning environment."

In traditional classrooms, a teacher who knows the content presents it to students who do not know it. Thus, the focus in class is on presenting and transferring knowledge to students. In science courses, this usually means that the students' first exposure to the material occurs in the lecture hall. Outside of class, students are given "homework," such as problem sets or exercises, that help them make meaning out of lecture materials. In contrast, students in flipped classrooms are required to gather information on their own before coming to class. One possibility for moving the instruction to the "individual learning environment" is recording lectures, placing them online, and assigning them to students before they come to class. There is, however, more than one medium that students can use to gather information before coming to class. They can be assigned readings or referred to online resources such as websites, videos, and simulations. The objective is to move the information transfer outside of the classroom. Preparing students in this way does not mean that we expect them to understand everything before they come to class. They may still have many gaps in their understanding. Yet, there is no doubt that they are better prepared when they come to class.

— So, what happens in class then?

Teachers' roles during class time change in flipped classrooms. Instead of focusing on presenting information, teachers focus on the significant gaps that students may have in their understanding. Teachers use subject matter and teaching expertise in class to help students make meaning of the information they gathered before class. Teachers help students create connections between new and prior knowledge, usually by giving more complex assignments in class, much like the kind of exercise that traditionally would have been given as homework. Hence, the term "flipped": what is usually seen as homework is now classwork, while traditional classwork becomes homework.

WHY FLIP?

Did you ever think about what the most expensive resource in a classroom was? More than the computer, projector or digital blackboard combined? That's right, the teacher. So, what sense does it make to use the most expensive resource as if it were a book, when you already have a book?

The idea of the flipped classroom is simple. Teachers have expertise. Expertise is more than the quantity of facts and concepts they know. It is better described as the way teachers connect these elements into coherent and meaningful conceptual structures that they know when and how to use. The role of teachers in flipped classrooms is better aligned with their expertise.

Instead of presenting information, teachers help students connect the information they gathered before class into meaningful chunks. Teachers help students overcome their conceptual difficulties and help students recognize when and how to apply the newly constructed knowledge.

WHAT WE DID: THE FLIP-JITT

We used LON-CAPA[2] as a course-management system to find out what our students knew and monitor what they were doing *before* they came to class. LON-CAPA is an online course-management platform like BlackBoard, Moodle, and LEA. These platforms allow communication between students and teachers, enable teachers to place content online, and let them give online assignments. We chose LON-CAPA because it is an open-source platform (i.e., free) and has lots of science content. We prefer not to describe the LON-CAPA platform in too much detail, because the Flip-JiTT approach can be used on any course-management system. We focus on how we tweaked the standard JiTT procedure (see Figure 1).

1 [www.flippedlearning.org]

2 [http://www.lon-capa.org]

FIGURE 1 — THE FLOW OF OUR FLIP-JITT SIDE-BY-SIDE WITH CONVENTIONAL JITT.

FLIP-JITT	JITT
1. What do you know?	
2. Information Gathering	Information Gathering
• Assigned textbook reading • Computers simulations • Online video tutorials	• Assigned textbook reading
3. Warm-up	Warm-up
• 4-6 online problems • Conceptual and numerical	• 2-4 Conceptual questions
4. Now what do you know?	
5. Reflect on what you've learned	
6. What do you still find hard or confusing?	What do you still find hard or confusing?

1 What do you know?

We began by asking students to reflect and state what they knew about a given topic. The first statement always was:

> *Before you start (…), it's important to establish what you already know about the topic.*

This was followed by topic-specific statements for each class, such as:

> *We've all experienced XXXX, whether we realized it or not. Using the space below, take 2 or 3 minutes to jot down 3 to 5 short sentences on what you already know about XXXX.*

2 Gathering Information.

Readings from the textbook were assigned. We also assigned links to relevant videos, websites, and simulations.

In our specific case, we made frequent use of PhET simulations developed by Nobel laureate Carl Wieman and his group at the University of Colorado. PhET are computer simulations that allow students to simulate the manipulation of a number of physical constructs. These simulations are extremely powerful in helping students visualize what happens in different situations modeled in their science course. We also regularly pointed students to online lectures by Walter Lewin at MIT (most often telling students which time intervals in a given lecture were most relevant). Selecting such online resources can be very time consuming and represents the bulk of the preparation time in this approach.

3 "Warm-up" problems.

We typically assigned 4 to 6 questions before each lecture. These questions ranged from simple single-concept questions to more difficult questions and, at times, slightly complex questions.

Students were not expected to have understood all the material before class. Most online assessment platforms allow instructors to set a fixed number of attempts on any given problem or assignment. We always gave them at least 5 tries, with no penalty for getting it wrong. They could, however, get an unlimited amount of tries if they came to see their teacher. In the past, we had observed students trying a problem 30 or 40 times before giving up. We put a cap of 5 tries and told them they could get more if they came to see us with questions. We also gave at least 48 hours to complete the "warm-ups," provided the time frame overlapped our office hours so that students could come for help if they needed it.

4 *Now* what do you understand?

For instance, the statement at the end of the assignment was:

> *Now that you had a chance to read the text and do a few problems, your understanding of XXXXX might have changed a little (or a lot). Take another 2 to 3 minutes to jot down 3 to 5 short sentences on what you now understand.*

5 Reflect on what you learned.

We displayed the latest entry of what they stated they *now* understood side-by-side with their initial statement. This was framed as follows:

> *Before you started, you wrote the following:* → *[initial statement].*
>
> *At the end, you wrote:* → *[latest statement].*
>
> *Take a few minutes to reflect on what you learned in this exercise. Write a short paragraph (5 to 6 sentences) on how your understanding has evolved.*

6 What do you still find hard or confusing?

Students were asked: "What questions, if any, do you still have about the material covered in this "warm-up"?

What areas would you like to cover more thoroughly in class?

Is there anything you still find confusing?

If not, please state what you found to be the most interesting.

This last item was added to make sure that students always wrote something. Otherwise, they would be far too tempted to write: "I found nothing confusing."

WHAT WE FOUND USING FLIP-JITT

Using these LON-CAPA warm-ups enabled us to track what our students did before class. Grades were given for these warm-ups, so students had incentives to participate. Tracking student participation revealed a compliance rate of 83% (we calculated the product of the number of students enrolled with the number of warm-ups assigned and then calculated the ratio of students participating in assignments over the total number of student assignments). We no longer needed to find out if students had done the reading, because they had to answer the warm-up questions. Whether they did the reading or not, they had to gather enough information to understand some basic problems and solve them. They might not have read the textbook. Instead, they may have listened to an online lecture, looked at a website, or played with simulations. One thing we knew was they were sufficiently prepared for class. But we were not prepared for what happened next…

The conclusion remained counter-intuitive to us: lectures can be useful *if students are properly prepared. Our heads are still spinning from that flip.*

Since we had taught the class many times, our classroom materials, conceptual questions, and notes were fairly polished. We entered our classrooms as usual, quite matter of factly. Following the JiTT-Peer Instruction script, we began the class by addressing students' difficulties, briefly lectured, presented the students with a first conceptual question, facilitated peer discussions, and followed up with a simple single-concept problem. To our surprise, students were somewhat irritated by this. Why were we giving a brief lecture on what we had already made them read? And had we not asked them similar kinds of questions before class? Indeed, we had! By tweaking JiTT, we had pushed most of the content outside of class and inadvertently flipped our classroom! We were stumped. What should we do now?

RETHINKING OUR TEACHING

Faced with an unexpectedly flipped classroom, we looked for student-centered active-learning activities to do in class: interactive lecture demonstrations (Sokoloff & Thornton 2010), more complex problems similar to collaborative group problem-solving activities (Heller & Hollabaugh 1992; Heller, Keith, & Anderson 1992). We were slowly trying to take ownership of our inadvertently flipped classroom.

This educational approach came with side effects. Certain unplanned events occurred that we had never seen in all our years of teaching. Pressed for time, we failed to systematically prepare thorough warm-ups for the last few classes. Before one of these classes, a few students came asking for the chapters to read before class. In our many years of teaching, we had never had a student come to ask which chapter sections to read *before a class*. We had often been asked what to read to prepare for a test, but never for a class. The most surprising side effect, however, was one that flipped our own understanding of teaching and learning.

We were not quite sure what to do when we realized that we had flipped our classrooms. So, we started by ruling out what we believed we shouldn't do. One thing seemed clear: lecturing was out of the question. We had read the papers (and written a few) and attended (and given) talks and workshops on why lecturing just does not work (Mazur 1997; Hake 1998; Meltzer & Thornton 2012). Then a question arose in class during one of the problem-solving sessions. Although we had explicitly acknowledged that we should not lecture, one of us (NL) dove right into a lecture-mode explanation. Surprisingly, students were more attentive than ever. Questions and classroom discussions arose. Nowhere in recent memory could we find an instance of this level of engagement in any of our lectures. Could a lecture actually be useful? Upon reflection, we recognized that students might have been more engaged because they had been properly prepared for the lecture.

Based on first-hand experience, we got more out of academic talks (lectures) when we knew more about the subject (and occasionally dozed off when we didn't). There is nothing new there. In fact, it was the core idea in a well-known learning-sciences paper called "A Time for Telling" (Schwartz & Bransford 1998). When properly prepared, students are ready to listen and process the information presented to them. The conclusion remained counter-intuitive to us: *lectures can be useful* if students are properly prepared. Our heads are still spinning from that flip.

CONCLUSION

When all the material cannot be covered in class, instructors use JiTT to push part of the course material outside of the classroom. We found that a simple tweak of JiTT, which we call Flip-JiTT, can easily lead to flipping the classroom because most of the coverage happens before class. We started out looking for active learning methods that would move us away from lectures. Surprisingly, we found that when prepared the right way (e.g., with Flip-JiTT) students can be engaged by lectures too.

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