

Context Dependence of Teacher Practices in Middle School Science

Noah S. Podolefsky and Katherine K. Perkins

University of Colorado at Boulder – 390 UCB, Boulder, CO 80309

Abstract. Conventional wisdom is that teachers have a model of teaching that they enact in the classroom. We studied middle school science teachers and found that the conventional wisdom does not explain large variations in practices for the same teachers in different contexts. During a study of PhET simulations, we observed two teachers in their regular (non-sim) classes and then in after-school classes in which they used PhET sims and activities developed by the PhET group. These activities were designed to be student-centered and inquiry-based. We find that one teacher led student-centered, inquiry-based activity in their regular classes but, in the after-school classes, controlled the classroom so that the sim activities were teacher-centered. The other teacher led teacher-centered regular classes, while enacting the sim activities in student-centered ways. We observe that teachers' practices can be significantly different across contexts, suggesting a sophisticated view of teacher practice is needed.

Keywords: simulations, middle school, teacher practice, context

PACS: 01.40.Fk, 01.40.gb, 01.50.ht

INTRODUCTION

Teaching practices are often divided into two categories, *teacher-centered* and *student-centered*. [1] In teacher-centered classrooms, the teacher has key ownership of the learning that goes on, being the source of both the questions and answers. In student-centered classrooms, students take ownership of their own learning while the teacher provides a guiding role. No classroom is purely teacher- or student-centered, but today education research favors student-centered learning, with good teacher facilitation and feedback.

Somewhat ironically, the responsibility for creating student-centered classrooms is generally placed on teachers. It is assumed that teachers' beliefs or "mental models" of teaching determine their practices, and so in order to enact student-centered practices teachers must have corresponding models. [2] Teachers certainly have ideas about teaching that influence what they do in the classroom. However, our research in middle school science classrooms suggests that teachers do not have simple, singular models of teaching. In fact, we find that, viewed within the framework of student- vs teacher-centered, classrooms with the same teacher can have radically different biases in terms of who is in charge of the flow and the learning. These differences can be seen both across classes and within the same class at different times.

Other researchers suggest that adaptation and improvisation are important teacher skills. [3] Since no two classrooms or students are the same, teachers who listen to and react to what students say must be able to make teaching moves on the fly. This view allows for

differences from moment to moment in reaction to local circumstances. However, one might conclude that a teacher with a student-centered view would always try to make moves that support a student-centered class. Our findings show that teachers who create student- (or teacher-) centered classes can create the exact opposite in another class held *just hours later the same day*.

BACKGROUND

The PhET project's prior work has focused on the college level [4]. Our present efforts are to produce sims and activities aimed at middle school. Over the last year we have worked with teachers at two public, K-12 charter schools in Dallas, with >90% Hispanic students and an aim to prepare for college-success.

We began collaboration with teachers from these schools by meeting in Colorado. We first met with the teachers to describe the PhET project, share our goals and philosophy about sim use and activity design, and get insight into how the sims could be used effectively in middle school classes.

Following this meeting, we traveled to Dallas and observed and video recorded classes in these schools. Two of these classes were regular in-school classes with no sims or other intervention from researchers. Our only role was to collect data on what teachers typically did in their classes. The other two classes were held after school with the same teachers. These classes used sims and activities developed by PhET researchers in collaboration with the middle school teachers.

CLASSROOM DATA

We present data from in- and after-school classes to demonstrate how these classes proceed in time, the role of the teacher, and the activity of the students. We focus on classes of two of the teachers - "A" and "B".

In School Class A: This is 5th grade science taught by teacher A. These students are studying motion and force, and this activity involves learning about what makes cars move. There are 20 students, sitting at 5 clusters of 4 desks each. Each student has a partner. The teacher can easily walk around the classroom and in between desks. The class starts with students entering and beginning a "do now", which is a short assignment to be completed before the main class activity. Below we outline the class flow with time stamps (min:s).

- 00:00 Students working quietly on "do now".
- 06:00 Teacher says time is up for "do now". Teacher goes through "do now" with students.
- 09:00 Teacher has students read aloud the learning goals of the main activity.
- 10:20 Teacher says "Today you're going to build your own super car."
- 11:00 Teacher shows pictures of different cars on the projector. She asks students "what about this car is going to make it travel really fast and really far?" Students give ideas and teacher confirms. Students say "ooh" when shown some cars.
- 18:00 Teacher says "now I'm going to give you instructions on your super car that you're going to build today. You have four things that you're going to have to do with your car. You're going to have to build a super car that will be able to go down a flat surface ... without you touching it at all. I want you all to just quickly brainstorm ... how could you make something move without touching it at all? Go ahead and just whisper to your partners for about ten seconds and then we're going to share."
- 18:52 Students talk to each other, then teacher has them share ideas with the class.
- 20:15 Teacher explains the car building activity. Students will build cars and make them go down a ramp onto tile and onto carpet. There are two tables with supplies including different sizes of wheels, sticks, tubes, tape, etc. The teacher specifies how many of each thing students can use. Teacher says students should find their "successful spot" in the room to work.
- 27:00 Teacher calls students in groups to get supplies. Students get supplies then return to their spots. Some work on the floor, some at their desks. While students work, the teacher roams the

room talking to groups of students. She does not give specific directions. Students make many different kinds of cars.

- 33:00 Teacher reminds all students to think about how to make the car travel as far as possible.
- 45:00 Some groups are rolling cars down ramps.
- 55:00 Teacher says to class "Okay boys and girls, please frozen icicles, eyes on me." Tells students they have ten more minutes.
- 1:05:00 Students are still working and rolling cars. Teacher has students put things away and store their cars in a safe place.
- 1:11:00 Teacher calls students back to their desks and says "raise your hand and tell me, what was one thing I did with my car that worked really well?" Students share ideas.
- 1:16:00 After discussion, teacher says tomorrow they will spend 15 more minutes on their car, "we could spend 15 weeks but we can't do that."
- 1:19:00 Students line up to leave class.

We consider this a student-centered class. In the first part the teacher leads the discussion, but takes input from the students and she constantly confirms their ideas. The teacher guides, while the student are significantly responsible for the knowledge being generated in the class. In the second part, the teacher gives very limited directions and allows the students to create their own objects (cars) and questions (e.g., what affects how the car rolls?). Students are working on their own, with minimal teacher intervention, for 55% of class time.

In School Class B: This is 6th grade science taught by teacher B. These students – all boys – are doing an experiment that involves counting the number of drops of water that fit on a penny. There are 27 students in this class, working in groups of two. The room is arranged into three rows of long tables with a wide aisle through the middle. The teacher was only able to walk up and down this aisle and back and forth near the front of the room.

- 00:00 Students enter classroom and go to their seats.
- 06:00 Students are silent, teacher explains that they will be doing an experiment today.
- 07:20 Teacher hands out lab worksheets and says "don't write on them." She stands at the front of the room, reading the introduction to the lab aloud to students.
- 09:00 Teacher asks students to read aloud the next several instructions for the lab. Teacher tells students to copy some of these instructions from the worksheets onto their own pieces of paper.
- 16:45 Teacher reads the problem "How many drops of water will fit onto the Lincoln side of a penny? That's your problem." Students write this down.

- 19:00 Students work together to guess the number of drops. The teacher's assistant says "take a guess, there's no way to know, it's a guess."
- 20:00 Teacher says "after you have made your hypothesis, you will write it down."
- 21:00 Students working in groups and talking to each other. The teacher's assistant asks students "Okay, why are you talking?" Teacher says, "because I told them to."
- 24:30 Teacher has students come to front of class and get equipment (water droppers, pennies).
- 28:45 Students back at their desks. The teacher says "look at number seven, it lists the procedure, the steps, everything you're going to do."
- 29:25 Teacher says "make sure you read the instructions, you must follow them step-by-step." Teacher and assistant roam room looking over students' shoulders and giving instructions.
- 35:45 Students have been working in groups talking to each other when the teacher stops them and says she needs "all eyes on me. Do not look down at what you're doing." Gives some instructions.
- 37:00 Teacher says they are out of time, students stop and return their materials.
- 40:00 Students line up to leave.

We consider this a teacher-centered class. The teacher takes control of what students are doing at almost every step. Even during the times when students are working on their own, the teacher explicitly reminds students to "follow the directions." Nearly all of the questions and the answers come from the teacher. Students work in their groups for about 40% of class time, but during this time they are following a strict set of instructions.

After School Sim Class A: This is a special after-school class made up of 5th and 6th grade students, taught by teacher A. The students work on an activity using two PhET sims, Balloons & Static Electricity and Electric Field Hockey. Students take pre- and post-tests around the activity. There are 6 groups of 2 students, each group with a laptop that they share. The arrangement is the same as In School Class A. The teacher can easily walk between the desks.

- 00:00 Students are at desks. The teacher introduces herself and hands out the pre-test.
- 01:00 Teacher reads the first question of the pre-test aloud to students. She has the students write down their answers.
- 02:45 Teacher reads the next pre-test question, has students write down answers. This continues through all pre-test questions.
- 12:00 Students are done with the pre-test. Teacher collects it and hands out the activity worksheets. The teacher hands out two air-filled balloons to

each group. The students rub the balloons on their hair, then try to make the balloons stick to each other, their clothes, and the walls.

- 16:00 Teacher has students sit and says "eyes on me."
- 17:30 Students tie a string to their balloons and see what happens. Teacher asks students and some students say "they bounced."
- 22:00 Teacher has a student read the learning goals listed in the activity aloud. Teacher asks the class "what are variables?" A student says "things that change."
- 24:30 Teacher has students discuss first question from activity in their small group.
- 26:45 Teacher has students open the Balloons and Static Electricity sim. She says "take three minutes and just play around with the simulation." Students start to play.
- 29:00 Teacher stops the students and has them answer the next activity question. Students write.
- 32:00 Teacher instructs the students to move ahead in the activity, close the Balloons sim and open Electric Field Hockey. She reads the instructions aloud to the students.
- 33:40 Students working on the sim. Teacher roams the room looking over students' shoulders.
- 35:00 Teacher says "once you have your [puck in the] goal, quickly draw your strategy."
- 39:40 Teacher says "I'd like to stop you where you are, all eyes up here please. So now everyone should turn to the fourth page, and just take one minute to draw where you might put the pucks to use as few pucks as you can."
- 40:30 Students have not finished, but time is running out so teacher stops them and hands out the post-test. Students do post-test on their own.
- 48:30 Students hand in post-test then leave.

We consider this a teacher-centered class, very similar in overall structure to In School Class B. The teacher takes control over nearly all of the student actions, to the point of reading each activity question for them and dictating when they should be writing. The activity written for the sim included many open and conceptual questions to get students thinking deeply, but this was curtailed by the teacher dictating when and how students should be working. And in addition, because of the teacher's pacing, time for student use of the sim was cut short.

After School Sim Class B: This is a special after-school class made up of 7th and 8th grade students, taught by teacher B. The students work on an activity using the Sound sim. Students take pre- and post-tests. There are 6 groups of 2 students, each with a laptop that they share. The arrangement is similar to that in After School Sim Class A.

- 00:00 Students are at desks. The teacher introduces herself and the researchers that are in the room.
- 08:15 Teacher hands out the pre-test and says “I understand you may not know some of these answers.” Students then work on the pre-test in silence on their own while the teacher watches.
- 18:40 Students turn in the pre-test. Teacher brings out equipment for a demo: she has two tuning forks and asks the class “what kind of sound do you think the large one is going to make?” Teacher takes ideas from the students, then says “we’re going to find out in a minute which one.” She has two wooden boxes that amplify the tuning fork sound and rings both of them to show which has the lower pitch. Teacher asks students for examples of low and high pitch sounds and writes student ideas on the board.
- 26:00 Teacher says “Okay, this was to get you all thinking about the difference between low and high pitch sounds. And really, I’m not giving you anything else, like, I’m not going to go into specifics about what you’re going to learn today because the idea is for you to walk through the lesson using the simulation.” She then passes out the main activity. Students begin to work.
- 28:00 Students open the Sound sim. Teacher says “you all may talk to each other.” Students start whispering, then talking to each other.
- 33:30 Students are working in groups, writing on their papers. Sounds can be heard from the laptops (the Sound sim makes different pitches). Students are looking at the sim, pointing at the screen, making gestures and discussing.
- 42:00 Students continue to work, teacher continually roams occasionally talking to student groups.
- 58:30 Teacher stops the students to say they are out of time. Some students keep using the sim, and teacher asks them to stop again. Teacher hands out the post-test and collects activities.
- 1:10:00 Teacher collects post-test and students leave.

We consider this a student-centered class in many respects similar to In School Class A. The teacher begins by leading a discussion, but leaves the answer making to students. While students follow a worksheet similar to that in After School Sim Class A, here the teacher takes a more hands-off approach and allows students to move at their own pace. In this way, students can be seen exploring the sim for a majority of the class time, thinking about the questions in the activity, and taking control over their own learning. Rather than being a restrictive set of instructions, the activity serves as scaffolding for student-centered inquiry.

CONCLUSION

If one were not told which teacher was in each classroom, it would be easy to assume that In School Class A and After School Sim Class B had the same teacher (and vice versa). This suggests that teacher practices are the product of much more than individual teachers’ beliefs or models of teaching.

For the In School classes, the teachers selected the activities and enacted them according to their own plans. In the after school classes, the activity topics and sims were selected by the teachers, while the activities were written by PhET researchers, with some feedback from the teachers, and were designed to be student-centered and foster student-driven inquiry. In addition, during their visit to Colorado, we emphasized to the teachers the importance of student-centered classes and how to use the sims to this end. Teacher B seemed to heed this advice and switched, giving up control after school and allowing the students to pace themselves through the sim activity. Teacher A, however, allowed open exploration in school but controlled the after school class in such a way to turn a student-centered activity into a teacher-centered one. Note that these after school activities took place *only hours* after the in-school classes.

In order to understand these data, we suggest that teachers do have ideas or models of teaching that they bring with them to the classroom, but that these models are multifaceted and complex. Teachers adapt not only moment-by-moment, but also to broader structures of the classroom environment. These adaptations are not random or haphazard. Through discussions with these teachers, we can identify valid reasons for the teachers’ choices. Characterizing either teacher as holding teacher-centered or student-centered models would conflict with our direct observations of what the teachers actually did. We therefore call for ways of characterizing teacher ideas and actions that capture the varied and indeed sophisticated ways teachers make pedagogical decisions.

ACKNOWLEDGMENTS

This work is funded by the O’Donnell Foundation, the Hewlett Foundation, and NSF DRK12 #1020362. We thank the teachers, students, and the PhET team, especially Kelly Lancaster, Trish Loeblein, Mindy Gratny, and Michael Dubson.

REFERENCES

1. Barr, R. B. & Tagg, J. *Change* Nov/Dec, (1995)
2. Trigwell, K. & Prosser, M. *Higher Ed.* **32**, 77-87 (1996)
3. Harlow, D.B. *Sci Ed.* 1-22 (2009)
4. Wieman, C.E., Adams, W.K., & Perkins, K.K. *Science*, 322/682-683, October (2008)