1. Lesson Descriptions

Lesson 1
This lesson uses light boxes and plastic blocks to help students determine how light is bent when entering and exiting a block.

Lesson 2
This lesson assesses students understanding of their universal rule of how light bends in relationship to the normal angle by allowing them to predict and apply their knowledge of this rule to new and different situations. In addition, students are shown various situations that help them to make connections between the way light bends and the shape of the block being used.

Lesson 3
In this lesson, the teacher uses the light boxes to show that light is made up of different colors. He uses questions to guide and assess student understanding and furthers the understanding with a student led demonstration.

2. Observation Notes

Lesson 1

Time Code	Description	Mercedes Model
0:00	Recalling prior activities and knowledge, Stating objective, safety reminders, directions to set up the exploration	Instructional/building knowledge base
5:40	Group Predictions	Applying knowledge
10:00	Group Experiment to test how light is bent by triangular block	Building knowledge base
19:25	Explanation of results/demonstration	Developing understanding
25:05	Interpreting the results-making conjectures	Developing understanding
36:45	Group makes predictions and experiment to determine whether their conjectures are supported using a different shaped block	Applying knowledge
46:20-52:30	Lesson Conclusion – teacher restates rules and their proof and then instructs students to clean up	Instructional/building knowledge base

*See Appendix A for full observational notes

Building knowledge base – 21:15 – 40%
Developing Understanding – 17:20 – 33%
Applying Knowledge – 13:55 – 27%

Lesson 2

Time Code	Description	Mercedes Model
0:00	Recalling prior activities and knowledge, Stating objective, safety reminders, directions to set up the exploration	Instructional/building knowledge base
5:55	Group Predictions	Applying knowledge
14:40	Group Experiment to test how light is bent by triangular block	Building knowledge base
17:50	Explanation of results/demonstration Challenge to find one block to do the work of two	Developing understanding
29:20	Students asked to apply their rule to an unfamiliar situation – two triangles placed point to point	Applying knowledge
37:00	Students are again challenged to find one block to do the work of two	Developing understanding
43:13	Students set up a new exploration to bend light until they can see different colors.	Building knowledge base
47:20-52:00	Teacher calls what students have done creating a prism. He then gives them a piece of equipment (lens) that will do a better job of separating the light into colors and instructs them to write down all the colors they see	Building knowledge base

*See Appendix B for full observational notes

Building Knowledge Base – 17:52 – 34%
Developing Understanding – 17:43 – 34%
Applying Knowledge – 16:25 – 32%

Lesson 3

Time Code	Description	Mercedes Model
0:00	Set up of equipment, Recalling prior activities and knowledge obtained, offers a mnemonic device to remember this information	Instructional/building knowledge base
5:25	Small group discussions to answer the question of where the colors come from	Developing understanding
9:07	Whole group discussion to share student ideas with the whole class and asks individual students to talk about how they could disprove the theories of others	Developing understanding
16:50	Uses questions to present a real world application of what students are observing and discussing in the lab	Developing understanding
18:05	Teacher turns an equipment malfunction into a reminder of safety rules	Building knowledge base
19:00	Uses question to check for student understanding. This embedded assessment shows him that the majority of students have come the scientifically accepted conclusion that the colors are in the light.	Developing understanding
22:15	The instructor begins another whole class discussion about where the light comes from. Students are encouraged to speak one at a time so they can defend and question different theories.	Developing understanding
25:25	Teacher acknowledges that not everyone has agreed on one classroom conclusion, but restates the ideas of the majority	Building knowledge base
26:05-40:00	Teacher assumes that students need to accept this conclusion and moves on to a second question; "If white light can be separated into colors, then can we also put them back in?" Students use a handout to answer this question	Developing understanding

*See Appendix C for full observational notes

Building Knowledge Base – 7:00 – 18%
Developing Understanding – 33:00 – 82%
Applying Knowledge – 0 – 0%

3. Discussion of Objectives

Lesson 1 Objectives
Students will complete an exploration to observe how light is bent in relationship to the normal angle when using a light box and plastic blocks. Then, students will use this knowledge to create a universal rule for how light is bent by plastic blocks.

Lesson 2 Objectives
Students will apply their conjecture about how light is bent by plastic boxes to new and different situations. In addition, students will use the blocks to see that light is made up of the following different colors (red, orange, yellow, green, blue, indigo, violet)

Lesson 3 Objectives
Students will extend their knowledge of light by exploring what white light is made up of. Students will use the light boxes and blocks to discover the colors that make up white light and how to bend the light to reveal and hide the colors.

Dan's statements of objectives
Lesson 1 - "Figure out that you can predict how light will travel when it goes into and out of a particular media" media called plastic blocks
- Light travels in a particular manner
- Students will generate a rule to describe the way in which light travels

Lesson 2 - Connect the behavior of light using two triangles or diamond shape to a convex lens and a concave lens

Lesson 3 - Know that white light is made up of colors that are always in a certain order, but are not in equal amounts.

The objectives that I saw were very similar to those Dan had intended. However, there were underlying concepts such as convex and concave lens and the amount of different colors within the light that I missed as an observer. I'd also like to mention that several aspects that I observed as just a next step in a well planned lesson were actually embedded assessments developed on the fly by an expert teacher. I was shocked that the use of the concave lens was actually an assessment. The use of this activity took place so seamlessly that I didn't even notice the assessment taking place.

4. Embedded Assessments

Lesson 1
After 10:00, the teacher begins visiting with student groups to question their prediction and check on their observations. During this time he notices that students are somewhat distracted by some secondary reflective light. He stops the class and directs them to focus on the "main" lines that will lead students to create conjectures about how light is bent.

Lesson 2
5:57 into the lesson, the teacher rotates to each group after they've been asked to make a prediction about a similar, yet unfamiliar situation involving two triangular blocks. During this rotation, the teacher asks students to defend their predictions in order to check for understanding of the rule they discovered yesterday that states that when light enters the block it will bend toward the normal angle and when it exits the block it will move away from the normal angle. He uses the students' predictions and answers to his questions to guide his discussion until students realize that the rule should "hold" for this new situation.

5. Teaching for Understanding

Lesson 2
During this lesson, students are asked to make connections between their rule and the shape of different blocks in their kits. Building connections is part of the developing understanding portion of the Mercedes Model. In addition, the teacher is using new and different situations for students to test out and prove the rule that they developed in lesson one. These opportunities assist students in developing an understanding of the concept of light instead of just a knowledge base about it.

Lesson 3
At 5:25, the teacher recalls that students saw colors in yesterday's lab. He then poses a question for the small groups to discuss. Students are asked where the colors came from. The discussions that follow require students to defend their theories both in small group and whole class discussions. They are encouraged to disprove theories using what they know about the world around them.

This is a great example of teaching for understanding. He has presented the students with a situation. They have observed it and he then asks them why it has happened and uses discussions and questions to help guide them to the scientifically accepted theory.

6. Missed opportunities

Lesson 1
Time 36:45 – At this time, the teacher instructs students to complete another exploration. However, he does not say that they will be testing the rules that they just came up with. I wonder if it would have been better for the students to come up with a way to test their rules or conjectures about how the light will bend. This would have allowed students to demonstrate not only an understanding of the behavior of the light, but also of the process of inquiry.

Lesson 3
Towards the end of lesson three, the teacher asks students if they can put the colors back into the light. However, instead of allowing students to explore with their light boxes and blocks, he offers a work sheet that rigidly guides the lab.
I assume from the amount of times he states "line it up carefully" that it is difficult to find and make the angles necessary to bend the colors back into white light. However, I think it would have been beneficial to have students experiment for at least a short time to attempt to line up the

blocks on their own and discover whether it is possible. Some of the groups didn't realize that they had proved this even after completing the lab. At the very end of class, the teacher did allow the group to attempt to find their own way, but they were unsuccessful. Too many distractions from the rest of the class prevented him from guiding them any further.

Appendix A

Observation Notes
Lesson 1

0:00 – 5:38 (SET UP)

Recall previous work
States objectives – how the light is bending
Directions – puts students into group, reminds students of safety issues, lists materials in oral and written form, instructs students to get materials and set up, (students obviously have prior knowledge of set up because nothing was said and students got right to it.)
5:40
He then hands out papers – one per group. Once everything is set up, students then turn off equipment in order to hear instruction. Students use their prior experiences to predict what will happen when the light when they use a triangular block. Teacher helps students see how they will set up the experiment in order to help them make a prediction. Students feel very uncomfortable making guesses. Many are unwilling to say anything – they just want to find out.

10:00
Of course, once everyone makes a guess, students are able to test it out.

Teacher asks reasoning behind predictions to gain insight of student understanding. Why is this reflecting? – He does stop and explains why it doesn't reflect and why they might have predicted reflection.

He then brings attention back to him and then explains which beams the students should be focusing on. Then, students record their results onto a different picture. He does clarify how to draw the lines for some groups. The technical procedure for drawing the lines which will help them to understand what is happening with the light.

19:25
After all the groups have done both explorations, the teacher uses the overhead to tell students their results. He doesn't actually ask students to share their results. He then compares the light to flagpoles – which we call normal angles. However, he realizes that his drawing is not accurate enough and starts over. Some students seem to be taking notes. He is trying to get students to create a rule for what happens to light as it is bent by the block.

25:07
He gives explicit directions for students to write their rules. He goes from group to group. One groups work is "corrected" – teacher does writes in the light lines for them so they can make a correct statement about what is happening to the light and how the angle of entrance and exit compare to the "normal" angle. (I don't know what they normal angle is, but students are expected to know)

Teacher moves to each of the groups to check for understanding of what is happening to the light. He clarifies misconceptions in each of the groups until they see the desired observation. In some groups he actually says "it gets closer to the flags" to describe what has happened to the light as it entered the block.

36:45
The next part of the lesson has students using a different shaped block to bend the light. Students will also be using a different light set from the box. They are asked to predict what will happen to a single beam coming into the half circle. He has the groups draw in the normal angle as a flag pole (I now realize that the normal angle is the perpendicular angle). Then use the normal angle and their rules to make the prediction.
41:50
Students are then allowed to use the light boxes to record how the light is bent. Then, students are asked to check their rules with what actually happened. Then students can determine whether their rules are correct or not. Teacher meets with each group to demonstrate how the experiment proves the students' rules. Some groups require the teacher to redo the drawing of the lines in order for students to see the connection between what happened and their rule.

46:20
The teacher concludes the lesson by restating the rule that all the groups came up with. He explains that the last part of the exploration was used to prove their rules. Now, the class can accept their rules as truth and are told that they will use the rules tomorrow when they continue their learning.

Students are then given time to clean up.

The teacher then shares a student observation that the rule could be called universal instead of general. This rule will work for any light going into any plastic boxes anywhere in the universe.

At the very end of the class, the teacher has some social time speaking about lunch until the bell rings.

I wonder if it would have been better for the students to come up with a way to test their conjectures about how the light will bend. Also, the teacher never called their rules anything specific.

Appendix B

Observation Notes
Lesson 2

00:00
Recalling yesterday's lesson – rule involving the normal angle
Asks students to share the rule for how light bends going in and going out with regards to the normal angle. (embedded assessment)
Directs students to set up and allows them to get materials and get it done
Catches up student that missed yesterday's lesson by explaining the group's paper that he will join.
Again restates the rule involving the normal angle

Building knowledge base

5:57
prediction
Students are given a challenge to predict what will happen to the light when it shines through the same triangle that has been flipped "upside down". At this time the teacher also asks students to defend their predictions to check for understanding. (He wants them to apply the rule they learned yesterday)
As he rotates from group to group he is using questioning to determine student understanding and guide them to recall their rule. He uses their predictions and answers to questions to help them understand that their rule should "hold" for this new situation

Applying knowledge

(On a side note – I just thought about what my classroom would look like if I tried to have such in depth discussions with each of my groups in k/1. What are all the other kids doing? I'd like to have a video camera to capture all of the off task behavior that would be happening while I assessed each group ☺ These kids are contemplating and restating after the teacher leaves. I don't know what mine would be doing)

14:40

Students are asked to try and record what actually happens to the light. However, the students did ask why this happened but the teacher did not address it. Students were also asked to explain why their predictions might have been wrong.

Applying knowledge

17:50

He then describes what they've done so far with the bending of light. He then wants students to find another block that will bend the light in the same way that they've done using two blocks. He's challenging students to create a similar result so they will further their understanding of how differently shaped blocks will bend the light.
He checks in with groups to help them compare the different shapes to what they've already done. They need to say that the shape needed to do bend light in the given way needs to be thin on the ends and fat in the middle.

After the students chose, the groups needed to trace the light and the shape

Developing understanding

29:20 – 30:15

A side note on a different experiment happening in the room to answer a question

30:15
Applying their rule to an unfamiliar situation
Students then explore what will happen when two triangles are placed point to point. This again helps students develop their understanding of how the blocks will bend light with regards to the normal angle. Each time they are given a new situation, they complete tasks with more and more ease.
Again, he checks in with each group to ensure that they are applying their rule appropriately to each situation

Applying knowledge

37:00

Students are again asked to find one block to bend the light in a similar manner to the way they just saw two blocks bend. This activity furthers a students understanding that the shape of the block determines the normal angle and the normal angle determines the way that the light bends. Thus, the students are making connections between the bending of the light and the shape of the block (convex or concave)

Developing understanding

43:13
Set up a new exploration with one beam and the triangular block. Students are asked to get color out of the light. Students experiment with moving the triangular block in front of the beam until the see different colors. Students then list the colors they see.

Building knowledge base

47:20

Teacher restates what the students have done – “created a prism” – He then gives them a different lens to place in their light box to separate the light into different colors. Students can then see that the white light is made up of red, orange, yellow, green, blue, and violet light.

Building knowledge base

52:00 – end of lesson

Appendix C

Observation Notes
Lesson 3

0:00 set up of equipment, recalling lesson 2. Review the list of colors and determine if they are “in order”. Teacher list

2:10 Teacher asks students to dictate the order of the colors they saw yesterday and lists them on the board. He questions why he is hearing Indigo and asks what it looks like. Some groups just say purple instead of indigo and violet

Building knowledge base

4:16 Gives students the mnemonic device to remember the order of the colors of light. I think he could have done more to help students remember this.

Building knowledge base

5:25 Recalls that first they saw a thin line of colors, but they were still there and in the same order. Then asks "Where did they come from?" He then rotates to the groups to help them determine that the colors come from the light. He asks “does it come from the plastic? He uses the blocks to disprove some incorrect student theories.

Developing understanding

9:07 Moves the question from small group to whole group to get more ideas circulating in the room. Students share ideas. Some think it is coming from the light and some come from the plastic blocks and has to do with the angle of entry

10:15 Asks students to disprove another’s theory about a why it can’t be coming from the plastic blocks. She responds that a rainbow disproves that theory because there is no plastic box in the sky.

Developing understanding

This is a great example of teaching for understanding. He has presented the students with a situation. They have observed it and he then asks them why it has happened and uses discussions and questions to help guide them to the scientifically accepted theory.

It was great to see the student come to the realization that the color was in the light and the block and filter revealed them around 15:43

16:50 He then asks questions to help students make connections from this lab situation to a real world application of a rainbow made from spraying a hose

Developing understanding

18:05 Teacher interrupted by a group that has had a malfunction – he turned it into a learning experience and explains that this occurrence of the bulb melting is the reason they were not supposed to leave the filter in for an extended period of time. Nicely handled both in terms of classroom management and teaching in the moment

19:00 Checks back with all the groups to check for assessment*embedded assessment* When a student does not share the view that the color is in the light, he asks students to defend their answers to their group. When they don't understand he acknowledges the disagreement but does not immediately correct it. Instead…

22:15 He addresses the whole class again, with the debate and recognizes that they have yet to prove the answer to the question of where the color comes from. At this time, students are free to defend their responses and question those of others. The teacher encourages students to speak one at a time so they can do this. In addition, he does clarify how the "rainbow makers" and blocks work differently.

25:25 Acknowledges that they are still not in agreement, but does restate the idea of the majority by saying that white light is a mixture of light. We can take them out.

Building a knowledge base

26:05 He then asks if they can put the colors back in? A student makes a connection to chromatography, but teacher is able to redirect students back to light. They are encouraged to try to do it instead of just answering it. Students use a handout to help them do just this.

I assume from the amount of times he states "line it up carefully" that it is difficult to find make the angles necessary to bend the colors back into white light. However, I think it would have been beneficial to have students experiment for at least a short time to attempt to line up the blocks by themselves and discover whether it is possible. Some of the groups didn't realize that they had proved this. The teacher did allow the group to find their own way, but they were unsuccessful. He tried

Developing understanding