

## APPENDICES

### APPENDIX A. INTERVIEW QUESTIONS

#### Part 1: Personal Background / Previous Experiences on Learning and Teaching Science

1. I'd like to talk a bit about who you are. How would you identify yourself? What social or cultural markers- for example, race, ethnicity, religion, gender, language- are salient to your identity?
2. I want you to draw a timeline of your life. Through my questions, I hope we can do that.
  - a. Where and when you were born and grew up?
  - b. Where did you live and study from elementary school to the university years?
  - c. Why did you want to become a teacher? What was and is your motivation?
  - d. For how many years is you teaching science? Have you taught other subject areas, too?  
If yes, which ones and for how long?
  - e. Where did (at what school) you teach before? For how many years and which grades?
  - f. When did you start teaching here in this school? Which grades and subject areas you taught in here?
3. I know your connection and passion for the agriculture and farming that you mentioned me and shared with me before.
  - a. I wonder how did that part of your identity connects to your science teacher identity?
  - b. In what ways, do you see that relates to your approach to science and science teaching?
  - c. How do you think your personal background and experiences would connect/impact your way of teaching science?
  - d. How do you think your personal background and experiences would connect/impact your way of teaching science to students with diverse backgrounds and needs? (based on your students' socioeconomical background, race or ethnicity, gender, language, special needs)?
4. Recently, you were also talking about your communication with parents and how important for you to building these relationships with families. Especially I remember when you invite the parents who are into falconry during the Bird Unit. I think it was a meaningful way to bring that home, family, and community connection to school and science. What would be your thoughts on that?
  - a. I wonder how do you center family and community connection in your science teaching?
  - b. Could you tell me more about that?
5. What's your philosophy of teaching science? What's important to you in teaching science?
  - a. What do you value in teaching science?

- b. How would you describe the ideal science teaching and learning environment? What is your and students's role in that space?

**Part 2: Experiences on teaching science with using ML-PBL curriculum and sensemaking practices & relationships with the parts of the system**

1. Can you describe your science teaching experience prior to ML-PBL?
  - a. What kind of science teaching and curriculum was it?
  - b. What kind of practices you were using? What was different?
  - c. When did you start teaching ML-PBL?
  - d. How do you think ML-PBL is different than your previous teaching? In which ways?
  - e. How did you become aware of ML-PBL? How was your interaction with your administrator and with the curriculum coordinator as you start using this new curriculum?
  - f. How was your learning process of the curriculum and these new teaching practices?
  - g. What was your experience on being a part of professional learning community?
2. You were working with Sarah as kind of the co-instructor. What was the nature of your collaboration?
3. How about your relationship with your school, your administrators, the curriculum coordinator, like the part of the community/system in your science teaching.
4. Do you think your science teaching has changed over the years? If yes, in what ways do you think your teaching changed? Can you give me some examples?
5. Now let's dive more into your teaching of ML PBL using sensemaking practices. I would like to go through your engagement and use of each of these practices now.
  - a. What sensemaking practices do you think help your students to make sense of or figuring out science phenomena?
  - b. How do you think those practices serves to that purpose?
  - c. Over the four years, how do you think you use driving question and driving question board?
  - d. How do you think that your and students' use of modeling and building artifacts and having indoor and outdoor investigations support students' sensemaking?
  - e. How do you think that you and your and students use of discourse moves over years?
  - f. How does ML-PBL help you to make connections with other subject areas? Especially how does it connect to math, literacy and students writing and reading skills?
  - g. In what ways, sensemaking practices and ML-PBL guide you to support students, especially from diverse backgrounds considering the context of your classroom and your school?
  - h. How do you think ML-PBL provide guidance to work towards more equitable and justice-oriented science learning environment for all students?
6. Based on what we talked before and after some of the specific focal lessons, especially the tree lesson with equity and SEL goal in the Squirrel Unit or where you read a book about Lonnie

Johnson story or family interviews lesson in Bird Unit... So, I want to talk a little bit about those specific lessons. Could you tell me more about your experiences in teaching those lessons?

7. How do you know if your students make sense of the science ideas? How do you assess their learning?

8. How do you support students to develop science identities that allow them to position themselves as experts and knowers in science learning?

9. How do you feel about your developing changing science teacher identity over the years?

10. In terms of the future orientation for your science teaching, how do you see your future science teaching? Do you plan to change things in your instruction? In what ways?

## APPENDIX B. THE ANALYSIS TABLE FROM THE YEAR 1

This shortened table provides a glimpse of how I analyzed and spot critical moments where Ms. Spark and students implemented six core sensemaking practices. For the full version, contact the author.

**Table 10.** The Analysis from the Year 1 (2018-2019)


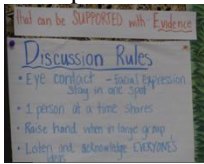
Y1: 2018- 2019	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 1 Unit/ Lesson <b>SQ_LS 4.2</b>	<p>1. Before introducing the DQ, T give some time to students to reflect back on the timeline. Her questions are more general at this point:</p>  <p><i>The last time we got together, we were trying to learn a little bit more about the Stegosaurus and his, um, the environment. And so, we created a timeline.</i></p>	<p>The discussion post is not necessarily in the curriculum</p> <p>Prioritizing going through the rules of discussion, setting the discourse norms (that I haven't seen any other classes- see the classroom picture). I can say that it made a difference. Below they are discussing about picture:</p> 	<p>1. Here, before teacher saying anything about what resource or evidence we have, student referred to the article they've read together, which could show Ss understand the importance of presenting evidence to their claims (picture from the class):</p> <p><i>T: Okay, so you think we're going to learn a little bit about, um, maybe some of the plants like?</i></p>		<p>Towards the end of the class, T highlights all the conversations, discussions, and videos they watch and guide students to work together to set the timeline of the events. T brings that 4 picture on the ground for students to work with and decide together- it's a pretty good discourse round and T give them a space to freely share/agree and disagree with each other:</p> <p><i>T: All right, so thinking about what we learned from our timeline?</i></p>		<p>Going constantly back to the previous lesson (building on prior knowledge)</p> <p>Teacher's language/choose of words: <i>We were trying to learn more about the Stegosaurus</i> Learning about vs. figuring out</p> <p>The way of introducing unit and lesson DQ (not referring back to students' Qs or DQB)</p>

Table 10 (cont'd)

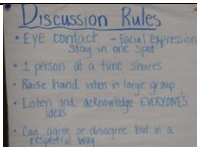

Y1: 2018- 2019	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 1 Unit/ Lesson: <b>SQ_LS 4.2</b>	<p><i>I put it up here so you can kind of see it. So think back to that activity. What did you learn about Stegosaurus? Um, when we did this activity. So turn and talk to your neighbors.</i></p> <p>2. After students turn and talked about timeline, T introduces the DQ. Knowing how she introduces the DQ in the following years, I can see that she is figuring out the lessons, DQ etc.:</p> <p><i>Let's look at our big driving question is, why do we see so many squirrels, but we don't see stegosauruses.</i></p>	 <p><b>T:</b> Turn and share. Show me that you're ready. Make sure you're crisscross applesauce and your eyes are up here. Riley, what do you notice?  <b>S:</b> It looks like there's plants.  <b>T:</b> In that picture. All right, so they look like some type of plant.  <b>S:</b> There's some kind of bone on the ground.  <b>T:</b> Okay, so she said this thing right here looks like a bunch of bones. Um, Jaren.  <b>S:</b> Um, there's something that looks like a carrot right there.</p>	<p><b>S:</b> Because in the article we read, it said they didn't eat like other dinosaurs. But they ate plants.  <b>S:</b> Okay. We might learn a little bit about the plants and maybe what the maybe what they ate.</p> <p>2. Teacher shows the pictures from different time periods reflective of the timeline. Her colleague also takes an active role in capturing students' ideas and building on classroom consensus (knowledge building process)</p>		<p>recent today and then thinking about our video that we watched. Do you remember the one with the Stegosaurus and the little creature? Remember that. Thinking about that, <b>we're going to try to put these in order from what we think is most longest ago to the most recent. So, stand up and form a circle.</b></p>  <p><b>S:</b> All right, so looking at the different time periods, post posters or pictures, which one do you think would be the most longest ago? Which one do you think would be the</p>		<p>Level of depth in navigating discourse (beginning low and becomes moderate)</p> <p>Going through Discussion Rules</p> <p>Collaboration with the other teacher (Sarah)</p> <p>Active group work through the timeline and pictures (beautifully going through each of them as students raise their noticings, at the end they have a class consensus chart-ish)</p>

Table 10 (cont'd)


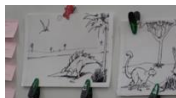

Y1: 2018- 2019	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 1 Unit/ Lesson <b>SQ_LS 4.2</b>	<i>We want to try to answer that second part, because we've talked about squirrels and their structures and how that helps them to survive with other in their environment, with other organisms. So today we're going to talk about what were the past environments like. So now we're going to focus on the Stegosaurus and we're going to work backwards. So how did the Stegosaurus survive in his environment. What structures did he have. What do you think we're going to talk about with our, um, learning our, uh, lesson question today?</i>	<i>T: Okay, let's get a little bit like a shape, like a carrot. Anybody want to add to what he said about that creature there, Claire?</i> <i>S: It looks like a unicorn.</i> <i>T: Um, boys and girls, I want to remind you our discussion rules is one person at a time. Our rules are right up there. So, turn and look up there so I can remind you. When someone is sharing you make sure that you use eye contact and that you're sitting still. Only one person at a time shares. You raise your hand when you want to share something,</i>	using these images (see the picture). T also capitalizes the word <b>noticing</b> which guide students to express their own observations and ideas (making them prepare for notice and wonder charts)    <i>T: I have some pictures of different time periods</i>		<i>longest ago?</i> <i>Brody?</i> <i>S: The first one.</i> <i>T: What do you think? Why?</i> <i>S: Because it's a dinosaur.</i> <i>T: Okay, so he says he thinks that this one was the one that happened most longest ago.</i> <i>Because he says it has a dinosaur in it. All right.</i> <i>Anybody want to add to what he said, or do they want to come up with their own idea?</i> <i>S: Um, I disagree with Brady because, um.</i> <i>S: Because we kind of know a lot about dinosaurs now. So if you since it's now we're learning about it, but, um, we like don't see those and see that often.</i>		Students work in circle and try to figure out the timeline of each creature was born and lived, T never leads or impacts students thinking, basically revoices their claims and affirms that students can come up with different claims  After putting the pictures in order, teacher introduces students with number of articles so they can bring evidence to their claims and rework and finalize

Table 10 (cont'd)

Y1: 2018- 2019	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 1 Unit/ Lesson: <b>SQ_LS</b> <b>4.2</b>	<i>What were past environments like turn and talk to your neighbors. Well, <b>what do you think we're going to talk about your question.</b></i>	<p><i>So. raise your hand and add on to what Jaren said in a respectful way.</i></p> <p><i>S: Looks kind of fiction, because I don't think it's true that carrots can be like.</i></p> <p><i>S: Um, would you think it looks like I think it.</i></p> <p><i>S: I think it still, I think it just looks like a plant with, like a dead plant.</i></p> <p><i>T: Okay. So she says it kind of looks. Reminds her of a little bit of, like, a plant. Brody, what do you think?</i></p> <p><i>Student: Squid!</i></p> <p><i>T: Okay. Kind of like a squid like creature. John?</i></p> <p><i>S: Along with what he said because it kind of looks like a squid.</i></p>	<p><i>during that fit in our timeline. So, I'm going to show you the different pictures. I want you to think about what you notice in them. So, this is the first one. Turn and talk to your neighbors about what you notice.</i></p> <p><i>S: I noticed that it um, it like bends over to touch the ground, I guess. like the dinosaur. Like tips it and it makes its tail go up.</i></p> <p><i>S: I notice there's a lot of palm trees.</i></p> <p><i>T: Okay, so what does that tell you about what it would be like there?</i></p>		<p><i>T: All right. She thinks this is the one that's the longest to go because these are, um, organisms that we probably wouldn't have seen today or the most recent. All right. Anybody want to add on to what they said. Jaren, what do you think?</i></p> <p><i>S: I think that fishy thing goes right there.</i></p> <p><i>T: Okay. Why? Um.</i></p> <p><i>S: Because that looks like a cat and that looks like a rhino.</i></p> <p><i>T: Okay, so why do you think that would be the most recent, then?</i></p> <p><i>S: Um. Because it's A Komodo dragon</i></p>		<p>their timelines</p> <p>Connecting the info in the articles as a type of evidence to support claims in determining timeline</p>

## APPENDIX C. THE ANALYSIS TABLE FROM THE YEAR 2

This shortened table provides a glimpse of how I analyzed and spot critical moments where Ms. Spark and students implemented six core sensemaking practices. For the full version, contact the author.

**Table 11.** The Analysis from the Year 2 (2021-2022)

Y2: 2021- 2022	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 4 Unit/L esson: <b>ToyLS 1.1</b>	<p>Brief reminder of the previous lesson, introduction of the unit DQ; not much discourse around the DQ itself though</p> <p>T: Just as a reminder, our driving question for our unit is how can we design fun, moving toys that other kids can build? And we started to share some family stories about maybe some parents, maybe some grandparents that maybe made some toys or had some toys that</p>	<p>Teacher let students to figure out the goal and reasoning of the investigation they are gonna do. She uses discourse prompts to support students to come up with the connection of how the investigation would help to figure out the DQ (why they do that, what their goal there is, why their predictions are essential part of sensemaking!):</p> <p>T: And then if somebody is launching it what are you doing, what are you going to be?</p>	<p>After T went through the DQB, she transitions into explaining the investigation of the day. T introduces all 3 types of rockets that SS will explore:</p> <p>T: <b>We want to figure out is there a pattern to all of the toys that we use.</b> Or are there some things that make them different. And then maybe some questions that we might wonder about so that maybe we can that will</p>	<p>Teacher spends time to make sure defining some of the main terminologies and points of discussion. There was a good discourse as students coming to a consensus on what system and pattern of motion means.</p> <p>T: We started to talk about this one right here. <b>This is a system. What do I mean by system?</b></p> <p>S: System to make the rocket go.</p>	<p>After talking about DQ, system and pattern of motion, T invites a student to stomp a rocket so students can see the pattern of motion of the rocket:</p> <p>T: Let's have somebody launch the air rocket and we'll see what it does this time. All right. Grayson. Do you want to try it? We're going to watch to see what happens when he stomps it. All right. Let's do it one more time and let's see what we notice about maybe the</p>		<p>The way of introducing unit and lesson DQ (not referring back to students' questions or DQB in the beginning). However, T points out to the previous lesson to build things together.</p> <p>The wording changes into <b>figure out, explore, explain...</b></p> <p><b>Language related to CCC (Not just DCI)-this is valuable-influence of teaching materials-3d learning</b></p>



Table 11 (cont'd)



Y2: 2021- 2022	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 4 Unit/L esson: <b>ToyL S1.1</b>	<p>moved in different ways. So that might help us when we're trying to design a toy that other kids can build. We played around with this racket last right before break. I'm going to get this one out right here. We started to talk about this one right here. Remember this? We talked about that. This is a system. What do I mean by system.</p> <p>After Grayson stomped the rocket and Ss had a discussion, T went back to Ss previous Qs from the wonder board and make sure to</p>	<p><b>S:</b> standing back and watching.  <b>T: what are you trying to look for when you're watching it?</b>  <b>What are you trying to figure out?</b> When you're watching somebody launch the rocket, what do you think you're trying to notice? Avery.  <b>S:</b> A different or the same way they go and how it goes.  <b>T:</b> The ways that it moves the same, maybe the ways that it moves different, right? Is that what you're talking about? Anybody <b>wants to add to what she's saying.</b> What else are you going to look for? Maddie.  <b>S:</b> Pattern.</p>	<p>Help us to design a toy for another kid. We got these rockets right here.</p> <p>She shows the worksheet that they need to fill as they investigate (notice and wonder chart). She also assigns roles to make sure everyone is involved and its fair:</p> <p><b>T:</b> You're going to <b>explore three rockets today. One is the one we already explored this. That one's the large one.</b> This one's going to be the medium one.</p>	<p><b>T:</b> Yeah. System to make the rocket go. what are the parts of the system that make the rocket go?  <b>S:</b> the palm.  <b>S:</b> The tube.  <b>K:</b> The tube that runs from here to the pump there. Miles?  <b>S:</b> The stand that holds the rocket.  <b>T:</b> Tessa?  <b>S:</b> The rocket, the rocket itself and the air that goes into it.  <b>T:</b> Okay. All right. Anybody else? All right. You guys agree with that? Okay. The system has parts to it to make the rocket move and to work. We were also trying to when we launched it,</p>	<p>pattern, the thing that, um, the cycle or what happens over and over again.</p>  <p><b>S:</b> Whoa.  <b>T:</b> What did you notice? What are some things that you noticed? Why don't you turn and talk to your neighbors about things that you noticed about the rocket?</p> <p><b>Meaningful responses below:</b>  <b>S:</b> It was fast both times.  <b>T:</b> it was fast both times so was the speed of it or was it launched really fast both times? What else?</p>		<p>Teacher puts a good focus on defining some of the main terminologies and points of discussion. She facilitates a meaningful discourse as students define what <b>system</b> and <b>pattern of motion</b> means. T help students to come up with definitions by collecting students' ideas. In doing that she revoices S ideas, ask follow-ups and called out students' names to make sure to give them ownership.</p> <p>She uses turn and talks number of times to leverage whole group conversation.</p>

Table 11 (cont'd)

Y2: 2021- 2022	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 4 Unit/L esson: <b>ToyL S1.1</b>	<p>through them to address some of them and to add new ones:</p> <p><b>T: Okay. We asked some questions last time. I posted all our questions on the wonder board back there.</b> We had some questions. Let me just turn your bodies a little bit. And I'll just read a few of those questions that we had. Um, and maybe you're thinking of some more questions that you're wondering about right now.</p> <p>T: We kind of grouped them up to ones that were about the structure of it.</p>	<p>T: Patterns of what?</p> <p>S: Patterns of how it looks the same or it doesn't when we launch.</p> <p>T: Sure. Patterns of how it moves. Like maybe. How far does it go? How fast does it go? The speed of it. Maybe distance like the distance of it. So just like we looked at the pattern of this one, we noticed that each time it goes straight up wiggles, and then and then it comes right back down and bounces off the ground. You're looking for those things. What are the things you notice about how it moves. All right.</p>	<p>then this one's going to be the small one. Yep. All right. Turn your body so you can see the screen because you're going to take notes as you observe today. All right. This is going to be your, um, paper to take some notes as you are. Your team is launching the different rockets. You'll see rocket one I put large there so you can remember that that's rocket one. And then I put next to rocket two I put medium so that you knew it was this one.</p>	<p>we were trying to notice some things about how the rocket moved, and we were <b>trying to figure out</b> a pattern of motion. I wrote that up there, a pattern. <b>what does that mean, a pattern of motion.</b> How about you <b>turn and talk</b> to your neighbors about what you think the pattern of motion might be?</p> <p><b>T:</b> turn and share. What did you guys talk about? What do you think the pattern of motion is?</p> <p><b>S:</b> Maybe it like. It is like the pattern of motion keeps.</p>	<p>Hayden, what did you notice?</p> <p><b>S:</b> Like went up really fast and then it just like, moved around and came back down.</p> <p><b>T:</b> All right. So each time it went up really fast, wiggled around and then came back down.</p> <p>S: Wiggle around. That was going back down okay.</p> <p>T: While it was coming back down. All right. Tessa.</p> <p><b>S:</b> On the first time that he launched it, it wasn't all the way down to the rims and it didn't go quite as powerful. But the second time, when it was down farther. ...</p>		<p>After talking about DQ, system and pattern of motion, T invites a student to stomp a rocket, so students can see the pattern of motion of the rocket in action. As she does that students were able to observe the phenomena first-hand multiple times and share their noticing and prediction by building on each other's ideas.</p> <p><b>(Form of scaffolding-teacher modeling of instruction- Y1 to Y2)</b></p> <p>DQB helped T to transition to the new investigation that students will conduct on different types of rockets and their</p>

Table 11 (cont'd)

Y2: 2021- 2022	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collaboration)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 4 Unit/L esson: <b>ToyL S1.1</b>	Some of them were I wonder if the wings on the bottom, um, helped it go so high. We talked about the wings on the, on the rocket itself. Somebody asked, does the point make it go farther? Um, why does somebody ask? Why does it have a tip? Um, and then if there was a hole in the tube, what would happen to the rocket? Would it change the way it moves? And then we had some about distance and speed, the motion of it. Some of them were what direction would it go with and if it was windy...	<p>Very end of the lesson where there is a whole class discussion based on students' noticing and wonderings and shows how students construct the knowledge together and T was collecting students' ideas and acted like a moderator:</p> <p>T: Okay, we got like five minutes, and I want to just kind of wrap up with some things that we noticed, maybe that were different about the ways that the rockets moved, maybe some things that made them similar to each other. Let's just look at your notes. Emma? ...</p>	This is the rocket two. And then rocket three is the tiny one. The small one. That's this one right here. All right. So as your team is taking turns launching it so each person can launch at once, let's just say <b>that's that would be the fair thing to do.</b> And then if somebody is launching it what are you doing, what are you going to be?	<p>T: Okay, so something that keeps it moving. All right. What else? Maddie? Um.</p> <p>S: Even though the rocket doesn't always shoot up the exact same, it's the same. It's going through the same cycle to make this rocket go</p> <p>T: Okay. Did you guys hear that? She said even though it might not move exactly the same each time, she's saying it's kind of like a cycle. It does this a similar thing each time. Okay. Anybody want to add to what she said, Amirah?</p> <p>...</p>	<p>Final part of the lesson: Students work in their small groups to conduct their investigation; working on three different sized rockets to figure out their pattern of motions:</p> <p>One of the group's work and convo as they worked with the middle-sized rocket:</p>  <p>S1: I know that it pointed really straight up. Going straight and shake it on this. You see that one?</p> <p>S2: Let's talk about we're going to write our questions...</p>	<p>patterns of motion. In that way, this is one of the top lessons that includes many SMP interwoven in a deeper way.</p> <p>Teacher let students to figure out the goal and reasoning of the investigation they are gonna do. She uses discourse prompts to support students to come up with the connection of how the investigation would help to figure out the DQ (why they do that, what their goal there is , why their predictions are essential part of sensemaking!)</p> <p>...</p>	

## APPENDIX D. THE ANALYSIS TABLE FROM THE YEAR 3

This shortened table provides a glimpse of how I analyzed and spot critical moments where Ms. Spark and students implemented six core sensemaking practices. For the full version, contact the author.

**Table 12.** The Analysis from the Year 3 (2022-2023)


Y3: 2022- 2023	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collab.)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 5 Unit/ Lesson <b>SQ_L</b> <b>S5.6</b>	<p>T lets students know that they're going to read a story which connects back to their DQ and what they have figured out in the previous lesson.</p> <p><b>T: We don't really read stories too often, but this one's a really good one.</b> I think you'll like it. And it will help us to answer this question that we have up here. It says, where have scientists and other citizens found fossils from the Jurassic period.</p>		<p>She introduces the book and the character in the book. She uses the globe to show where the story takes place and shows how far is England from Michigan.</p>  <p>T: I'll show you on the globe where it where it's where she's at. We're right here. Here's Michigan, the United States.</p>	<p>T makes sure to navigate really interactive read-aloud discourse where she pauses many times in between the reading, showing the images from book; going through the meanings of certain notions with students, and most importantly asking lots of questions that where students can also bring their own personal experiences:</p> <p><b>S:</b> Because all those dinosaurs look like it's like a bunch of rhinos. And most of them kind of look like</p>		<p>T support students in bringing their own personal and family experiences on science phenomena (such as fossils) and what they have figured out in science lessons. In that way, T perfectly brings the literacy connection to the science and connect back the content of the book to their science phenomena. She also makes sure to ask about what experiences, characteristics and feeling that the character has and might been go through as a young kid and help</p>	<p>T lets students know that they're going to read a story which connects back to their DQ and what they have figured out in the previous lesson. This also shows that T doesn't necessarily goes through these read aloud SEL goal lessons, she included/taught this lesson as I visit her class.</p> <p>She introduces the book and the character in the book.</p>

Table 12 (cont'd)



Y3: 2022- 2023	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collab.)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 5 Unit/ Lesson <b>SQ_L</b> <b>S5.6</b>	<p>You were thinking of a movie? Apparently Jurassic Park. We've been talking about why we see so many squirrels, but we don't see stegosauruses.</p> <p><b>T:</b> We figured out that, um, it that if we find a fossil that will help us to gather evidence about what it was like back then during the Jurassic period, and then what other organisms will live there and maybe what happened to them over time. This is a story. It's called <b>Stone girl, Bone Girl</b>.</p>		<p>Over here across the ocean right here is where Mary Anning lived and grew up. So right over here. So here we are. Here she is over here.</p> <p><b>S:</b> It's like one ocean away. Oh, one ocean away.</p> <p><b>S:</b> So Atlantic?</p> <p><b>T:</b> Yep. Cross the Atlantic Ocean. So that kind of gives you a little bit of an idea of where she's from. So this if you look at this cover here, I'll kind of open it up because it's kind of a picture goes across the two pages. <b>What do you notice about the cover? What do you think this book is going to be about?</b></p> <p><b>S:</b> I think it's about, um, how she finds fossil in her homeland.</p>	<p>they're in the dark.</p> <p><b>S:</b> Um, it's like about dinosaurs and fossils.</p> <p><b>T:</b> Okay. Dinosaurs and fossils. What do you think, Stone girl? Bone girl is going to mean? Stone girl, bone girl. Lincoln?</p> <p><b>S:</b> She might find, um, like bones or fossils from the dinosaurs.</p> <p><b>S:</b> and stone.</p> <p><b>T:</b> Okay. All right. When Mary Anning was a baby, she was struck by lightning. I know it's kind of crazy, isn't it?</p> <p><b>S:</b> How is she not dead?</p> <p><b>T:</b> Sometimes people can survive. And she did it. Was it split a huge elm tree and threw Mary right out of her nurse's arms.</p>		<p>empathize with the character as a young kid, explorer, and scientist.</p> <p><b>T:</b> Okay. Dinosaurs and fossils. What do you think, Stone girl? Bone girl is going to mean. Stone girl, bone girl. Lincoln?</p>  <p><b>T:</b> I wanted you to think about. In that picture there you can see the cliffs and then the sea and all the rocks and stuff by the sea. So that can kind of give you a good visual in the head. Why, he she held on to her dad's hands so carefully.</p> <p><b>T:</b> The clay cliffs at Lyme Regis are soft as melting chocolate.</p>	<p>She uses the globe to show where the story takes place and shows how far is England from Michigan.</p> <p><b>T</b> makes sure to navigate really interactive read-aloud discourse where she pauses many times in between the reading, showing the images from book; going through the meanings of certain notions with students, and most importantly asking lots of questions that where students can also bring their own personal experiences. She also uses a video at the end that similarly covers the story of Mary Anning and her contributions to the science.</p>

Table 12 (cont'd)

Y3: 2022- 2023	SMP1 (DQ)	SMP2 (Discourse)	SMP3 (Multimodal)	SMP4 (Multiple literacy)	SMP5 (Collab.)	SMP6 (Working Towards Equity and Justice)	Takeaways from each class
Class 5 Unit/ Lesson <b>SQ_L</b> <b>S5.6</b>	T: It's a story about a girl named Mary Anning, and she's from, it's called Lyme Regis. I put a picture up on the screen so you could kind of see what it looks like.		<p><b>T:</b> Okay. And why do you say that?</p> <p><b>S:</b> Because all those dinosaurs look like it's like a bunch of rhinos. And most of them kind of look like they're in the dark.</p> 	Her father was in his carpenter's shop when he heard the terrible news. He dropped his hammer and ran through the stormy streets of Lyme Regis. Gently, he lifted the limp body of his little daughter, and his tears flowed like rain. But then an extraordinary thing happened. Mary Anning slowly opened her eyes. She reached out a tiny hand and touched the amazing face of her father, and the little girl began to smile. It was then that her father realized that Mary Anning was going to be no ordinary girl. It's pretty extraordinary, isn't it? ...		<p>Mary had sometimes seen huge slabs of land slipping and tumbling into the beach below.</p> <p><b>T: How many of you been up in the U.P. and you've gone to the pictured rocks?</b></p> <p>S: Me and my mom have!</p> <p><b>T:</b> You can <b>probably connect to that</b>, because sometimes what happens on the pictured rocks next to the lake. What happens to them?</p> <p>S: some of the rocks might fall</p> <p>T: They don't let you get real super close to the cliffs because they don't want you to fall off of it. ...</p>	T support students in bringing their own personal and family experiences on science phenomena (such as fossils) and what they have figured out in science lessons. In that way, T perfectly brings the literacy connection to the science and connect back the content of the book to their science phenomena. She also makes sure to ask about what experiences, characteristics and feeling that the character has and might been go through as a young kid and help student to empathize with the character as a young kid, explorer, and scientist.

## APPENDIX E. FINAL SUMMARY ANALYSIS TABLE

This shortened table provides a glimpse of how I summarized and recognized critical moments/arguments where Ms. Spark and students implemented the six core sensemaking practices in the 3 years across the 5-year span. For the full version, contact author.

**Table 13.** Summary Analysis to Illustrate the Core Changes in the Implementation Across the Years

<b>Year 1 (2018-2019)</b>	<b>The core changes (changing patterns) in the implementation from the beginning to the end of each year</b>
<b>SMP1 (Driving Question)</b>	<ul style="list-style-type: none"> <li>- Dynamic start but inconsistent focus on connecting back to previous lessons (through the discussions and investigations) and students' prior knowledge and experiences</li> <li>- T's consistent choice of wording during the year as she facilitates the discussion around the DQ and sets the learning goal of the lesson: "trying to <b>be learning about...</b>" and "trying to <b>answer the question...</b>".</li> <li>- Inconsistencies in introducing both Unit and lesson DQ during the lesson and visible integration and use of DQB</li> </ul>
<b>SMP2 (Discourse Moves)</b>	<ul style="list-style-type: none"> <li>- Setting the norms for a meaningful and respectful discussion and discourse environment (not so detailed but a nice start)</li> <li>- From using some of the discourse moves to using variety of them a) to make students' ideas visible and promote quality discussion about DQ and Qs from the DQB, B) to highlight and connect students' prior knowledge and experiences from their indoor and outdoor investigations, and c) to support students as they form claims and use evidence.</li> </ul>
<b>SMP3 (Multimodal Representations)</b>	<ul style="list-style-type: none"> <li>- Students start working with different multiple representations, such as articles, images, websites, and videos from to experience phenomena second-hand about different prehistoric eras, characteristics of variety of birds,</li> <li>- Students started to create multimodal representations, such as artifacts, consensus, and individual models, wonder and what I know boards, notice, and wonder charts etc.</li> </ul>
<b>SMP4 (Integrating multiple literacies)</b>	<ul style="list-style-type: none"> <li>- There wasn't much of math or literacy integration to the lessons to promote multiple literacies of the students</li> <li>- T makes sure to facilitate discussion when students encounter a new concept or term that they might not be familiar with. Through the discourse, students come up with definitions of the concepts drawing from their experiences.</li> </ul>
<b>SMP5 (Collaboration)</b>	<ul style="list-style-type: none"> <li>- Whole group discussions and small group work (indoor and outdoor investigations) constitutes the collaboration</li> <li>- Collaboration started to become a SMP that involves other SMPs as T and Ss conduct and share their investigations through using discourse, multimodal representations, and reflecting back on the DQ and DQB.</li> <li>- T started to develop a mindset and underlined constantly the importance of using evidence to support claims as students come up with their predictions and explanations</li> <li>- Investigations and artifact building started to become an important venue for students to experience and explain phenomena as they keep working on their C-E-R experiences to make sense of the phenomena</li> </ul>
<b>SMP6 (Working Towards Equity and Justice)</b>	<ul style="list-style-type: none"> <li>- Lack of critical connection to equity and justice. One of the lessons has an SEL goal of developing interest which was superficially connected back to students lives and interest.</li> <li>- T was enthusiastic about bringing her life experiences and family connections to the class, allowing students to know more about her, and start to build more meaningful relationships. It also encouraged Ss to bring their family experiences related to phenomena.</li> </ul>



Table 13 (cont'd)

Year 2 (2021-2022)	The core changes (changing patterns) in the implementation from the beginning to the end of each year
<b>SMP1</b> (Driving Question)	<ul style="list-style-type: none"> <li>- Consistent connection back to the previous lessons and investigations before starting a new DQ, so that Ss can construct the knowledge together using prior experiences to current experiences</li> <li>- T's choice of wording started to shift from Y1 as she facilitates the discussion around the DQ, and sets the learning goal of the lesson: "trying to figuring out...", "trying to explore", "trying to explain..."</li> <li>- Consistency in introducing Unit and Lesson DQ during the lesson; however, T lets students read and introduce the DQ: "you will teach others...", "you will research..."</li> <li>- Meaningful integration of Qs from DQB to the phenomena and investigations; but inconsistencies in using the DQB</li> <li>- T was much more vocal and nuanced on why they do the investigation and how what they do support/connect to their process of figuring out the phenomena/DQ.</li> </ul>
<b>SMP2</b> (Discourse Moves)	<ul style="list-style-type: none"> <li>- Variety and quality of using discourse prompts (also how/why follow-ups) increased</li> <li>- In-depth discourse about the DQ by bringing students' previous experiences and investigations</li> <li>- T's ability of collecting students' ideas and represent them as new knowledge- even when students didn't express their ideas explicitly, she was able to pick them up and rephrase in a way that make sense and further the discourse</li> <li>- The facilitators of the discourse also shifted to parents: Ted and Nina used various discourse moves smoothly to connect students' experiences and observations while making predictions and bringing explanations about birds.</li> </ul>
<b>SMP3</b> (Multimodal Representations)	<ul style="list-style-type: none"> <li>- Using and creating multiple representations greatly impacts and supports students' experiences in a) collaborating with the peers, b) finding different ways to represent, explain and make sense of science phenomena, c) building claims using evidence with reason, d) co-constructing knowledge</li> <li>- Starting at the end of the Squirrel Unit, equitable modes of modeling and representation increased. T started to prioritize what type of representations would be meaningful, relevant, and helpful for students to connect back to their previous experiences and present and explain phenomena in various ways such as through narratives, sketches, skits, drama etc.</li> <li>- Consensus models become a main tool especially during the Toy Unit for T and Ss to figure out how they can build individual models, to enrich the discourse by unpacking concepts.</li> <li>- Multiple representations become a tool to connect first and second-hand experiences for students as they experience phenomena (such as using their outdoor experiences of <i>Sit Spots</i> and <i>Wonder Walks</i> in Bird Unit to confirm/identify the local birds they see through Allaboutbirds.org)</li> </ul>
<b>SMP4</b> (Integrating multiple literacies)	<ul style="list-style-type: none"> <li>- T supports students in explaining central concepts (such as fair test, system, and patterns) by collecting students' ideas, drawn from their observations and everyday experiences. In doing so, T moved away from just unpacking concepts related to DCI with students, but also addressing the CCC.</li> <li>- Ss actively worked on investigations that promote and incorporate Math Literacy. Ss worked on identifying variables within fair test, using different unit of analysis, and measuring distances of motion on different surfaces.</li> </ul>



Table 13 (cont'd)

<b>Year 2 (2021-2022)</b>	<b>The core changes (changing patterns) in the implementation from the beginning to the end of each year</b>
<b>SMP5 (Collaboration)</b>	<ul style="list-style-type: none"> <li>- The interconnection and coherence among SMPs become more visible, especially among DQ, Discourse, MMR, and Collaboration through investigations</li> <li>- The collaboration in small group work (investigation) becomes a stronger component as students build, design, redesign solutions and present/act out their artifacts/models.</li> <li>- Small and whole group work become the main source of where students experience and predict how phenomena occur, collect evidence (that teacher constantly highlights), and explain phenomena during the process of figuring out the DQ.</li> </ul>
<b>SMP6 (Working Towards Equity and Justice)</b>	<ul style="list-style-type: none"> <li>- T works through students' struggles in writing and reading and works with students who prefers to use different modes of modeling through sketches, narrations, act outs etc., which becomes alternative and equitable modes of exploring, expressing, and explaining phenomena</li> <li>- T more explicitly start bringing family stories and family connections to the science phenomena</li> <li>- T's willingness to build relationships and communicate with parents stands out! She prioritizes bringing family and community connection and interest to the science classroom by inviting parents who are practicing falconry to support students' sensemaking experiences about local birds.</li> </ul>
<b>Year 3 (2022-2023)</b>	<b>The core changes (changing patterns) in the implementation from the beginning to the end of each year</b>
<b>SMP1 (Driving Question)</b>	<ul style="list-style-type: none"> <li>- The depth and quality of the discussion around the DQ peaks within and across this year. T and Ss masterfully connect each lesson DQ and goal of the investigations together to figure out phenomena using variety of discourse prompts.</li> <li>- T and Ss connect back to the prior lessons and investigations in each unit, however, students are the ones who bring all the knowledge together by connecting previous experiences to the new DQs through T's facilitation.</li> <li>- The intersection and coherency among multiple SMP are at its peak in each lesson during this year.</li> <li>- T prioritizes and focuses more on asking critical questions to make students think about the issues of equity, fairness, environmental justice, and who gets to become a part of science in society peaks in this year starting from SQ unit.</li> </ul>
<b>SMP2 (Discourse Moves)</b>	<ul style="list-style-type: none"> <li>- Since Y1, this is the first time that T goes through the norms of quality discourse. Unlike Y1, T unpacks different discourse moves to use express, building on, and explain ideas. As students set a baseline of what moves to use, the quality of discourse gets much better and higher level throughout the lesson starting from SQ unit.</li> <li>- T advances in gathering students' ideas and questions to summarize, synthesize and then finally revoice them as the collective knowledge that students co-construct throughout the lesson.</li> <li>- As Ss excel in using variety of moves to clarify and explain their thinking, they also start connecting their everyday experiences to science as evidence to support their claim without further T support.</li> <li>- The use of discourse moves peaks this year as students contextualize them to a) bring their family stories and cultural resources, b) connecting with 1st graders together through the interviews they conduct to redesign their toys, c) raise awareness on the social, economic, and environmental contexts and differences of various communities.</li> </ul>

Table 13 (cont'd)

Year 3 (2022-2023)	The core changes (changing patterns) in the implementation from the beginning to the end of each year
<b>SMP3</b> (Multimodal Representations)	<ul style="list-style-type: none"> <li>- Read aloud of the articles and books becomes the critical MMR tool in Y3 in terms of incorporating science to literacy and leveraging students' critical consciousness of the cultures and needs of different local and global communities.</li> <li>- Consensus and individual models, as well as end of unit artifacts become the core representations that students build together. T masterfully oriented students to use their representations to show how they notice, predict, compare, and explain the overarching phenomena as a part of their sensemaking in each unit.</li> <li>- Unlike in Y1 and Y2, T created sort of a buffet that includes at least 20 different materials that students can use to redesign and investigate their toys. This big range of materials were made of all accessible, everyday materials that students can use and test their ideas based on their imagination and curiosity.</li> </ul>
<b>SMP4 (Integrating multiple literacies)</b>	<ul style="list-style-type: none"> <li>- Besides incorporating Math Literacy (especially within Toy Unit), Y3 becomes the year that T and Ss actively use children's books and number of articles to facilitate read aloud experiences that merges science and literacy components together especially in Squirrel and Toy Units.</li> <li>- T masterfully navigates an interactive read-aloud discourse where she pauses many times in between the readings, shows the images from books or articles, goes through the meanings of certain notions with students, and most importantly asks lots of critical questions where students can bring their personal experiences, interests, and ideas.</li> <li>- T visibly guide students to see the connection between the texts they read and investigations they conduct. For example, as Lonnie Johnson was students were connecting how Lonnie Johnson redesigned his prototypes multiple times to test and improve his Super Soaker and how he showed the designs to the kids to see if they like it or if it works for them. This reminds students that they also designed and redesigned their toys and even show their designs to the 1<sup>st</sup> graders to get their feedback to strengthen their designs. Connecting the books and the experiences of scientists to students' experiences on learning science was masterful.</li> </ul>
<b>SMP5</b> (Collaboration)	
<b>SMP6</b> (Working Towards Equity and Justice)	<ul style="list-style-type: none"> <li>- Y3 was an exemplary year of using children's books to introduce students with community of scientists, inventors, engineers, and researchers from diverse backgrounds. For example, in Squirrel Unit, "<i>Stone Girl Bone Girl: The Story of Mary Anning</i>" guided students to figure out how Mary Anning discovered new fossils as a woman in the field of science and how her observations changed the natural science and history world.</li> <li>- The article of "<i>Trees Grow on Money</i>" made students realize, question and critique on a) how richer areas in the US cities have more trees and green areas, and what are the potential reasons behind those environmental inequities especially for communities with less resources, b) the ways to raise consciousness to the issues of environmental injustices and act towards equitable planting goals.</li> <li>- These critical texts and discourse in Squirrel Unit helped students to delve into the notions of what equity and fairness might mean in the context of science and society.</li> </ul>

Table 13 (cont'd)

Year 3 (2022-2023)	The core changes (changing patterns) in the implementation from the beginning to the end of each year
<b>SMP6</b> <b>(Working Towards Equity and Justice)</b>	<p>- In Toy Unit, reading “<i>Whoosh!: Lonnie Johnson's Super Stream of Inventions</i>” made students critically think about how love of inventing things was present in Lonnie Johnson's early life and how his passion for problem solving became the cornerstone of his career as a one of the lead African American engineers and scientists at NASA. Lonnie Johnson story guided students to discuss and critically reflect on a) how important to have an ongoing interest and resilience as a scientists to keep designing and investigating until make sense of and resolve the problems, b) how scientists have the endless curiosity and care as they building and designs inventions for other kids, and c) the historical, social, and cultural challenges that scientists from underserved communities face along the way of working to accomplish their goals. As they had these critical conversations, students were vocal about how they relate to Lonnie Johnson’s story and could see him as a role model as they also design toys for other kids and aim to become successful like him.</p> <p>- Centering students’ resources and promoting student-lead expertise peaked when students conducted peer interviews with 1<sup>st</sup> graders in Toy Unit, as well as when they shared family interviews in Bird Unit. Interviewing with 1<sup>st</sup> graders as they introduce their toys and get feedback on the design changes, helped students to develop critical skills of socio-emotionally connect and collaborate with their peers.</p> <p>- In addition, conducting family interviews were essential to bridge family’s historical and cultural stories, experiences, and resources to science phenomena, and to connect those different ways of knowing, and understanding the world around them. ---</p> <p>- Students get to learn more about how different birds can carry different special and emotional meanings for some families and cultures. As hearing students’ stories, teacher also opened up about her own family and personal roots and special connection to the certain birds and its reasons.</p>