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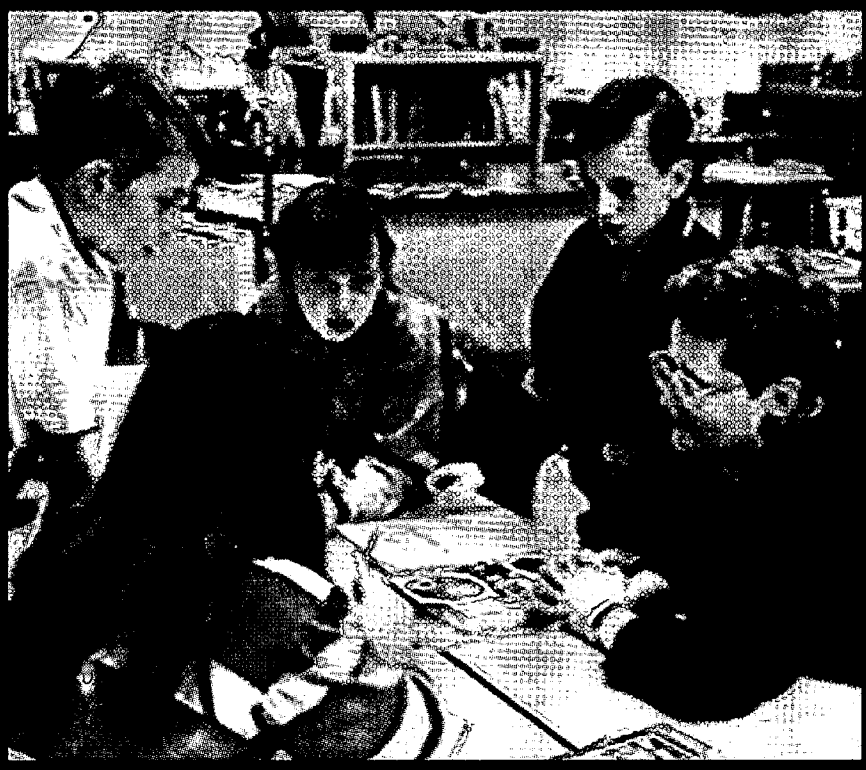
ABSTRACT

Items in the North Central Regional Educational Laboratory's (NCREL) School Development Library series are multimedia packages consisting of print, video, audio, and CD-ROM resources designed to support educators in their efforts to improve classroom instruction. This particular set consists of a 40-minute video and a printed booklet focusing on Linda Hallenbeck, a fifth-grade teacher. The video of her classroom shows her teaching a math lesson on probability incorporating coin flipping, spinner spinning, and die throwing. The lesson is a combination of whole group and small group hands-on, collaborative activities. The teacher asks probing questions to help children formulate their ideas about probability and encourages the children to express their reasoning and to listen carefully to each other. The lesson emphasizes that mathematics is about solving everyday, real-life problems, and there are many ways to solve a problem. It is actual footage of a fifth-grade classroom and is divided into 22 events, each division representing a change in the activities or flow of the classroom. The text of the booklet is based on spoken comments made by various people as they watched the video. The booklet's intent is not to be a verbatim transcript, but rather to capture the viewer's reactions to the classroom. (JRH)

School Development Library

A Fifth-Grade Math Lesson With Linda Hallenbeck



Linda Hallenbeck is a fifth-grade teacher. The 40-minute video of her classroom shows her teaching a math lesson on probability incorporating coin flipping, spinner spinning, and die throwing. Linda's lesson is a combination of whole group and small group hands-on, collaborative activities.

NCREL

A Fifth-Grade Math Lesson With Linda Hallenbeck

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NCREL's School Development Library consists of video and print resources designed to support educators in their efforts to improve classroom instruction. These materials include audiotapes, case studies, the *Pathways to School Improvement* Internet server, print guidebooks containing teacher and expert commentary, video programs and videotapes of actual classrooms, and CD-ROMs, which include both a classroom video and the guidebook in electronic format.

The classroom videos are not scripted; they provide an example of real elementary or high school instruction to be used as models or cases for educators to study. They are examples of good instruction that is consistent with established and developing content standards. These videos are designed to be used as part of an ongoing professional development program that includes the use of other classroom videos, information, and resources.

Some of this material was adapted from Strategic Teaching Framework (STF), an NCREL/IU hypermedia project, under the direction of Thomas Duffy, Professor of Instructional Systems Technology at Indiana University; Beau Fly Jones, Senior Researcher and Director of the Teaching and Learning Center at NCREL; and Randy Knuth, Director of the Center for Scaling Up at NCREL.

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Linda Hallenbeck

Suggestions for Using the Perspectives With the Video

Linda Hallenbeck is a fifth-grade teacher. The 40-minute video of her classroom shows her teaching a math lesson on probability incorporating coin flipping, spinner spinning, and die throwing. Linda's lesson is a combination of whole group and small group hands-on, collaborative activities. She asks probing questions to help children formulate their ideas about probability, and she encourages the children to express their reasoning and to listen carefully to each other's ideas. Linda emphasizes that mathematics is about solving everyday, real-life problems, and there are many ways to solve a problem.

The video is actual footage of a fifth-grade class taped over a two-day period at the end of May. The tape is divided into twenty-two events, each division representing a change in the activities or flow of the classroom.

The Linda Hallenbeck Perspectives booklet is designed to be used with the Linda Hallenbeck video. The text in this booklet is based on spoken comments made by various people as they watched the accompanying video. NCREL tape-recorded, transcribed, categorized, and, in some cases, condensed these comments. This booklet's intent is not to be a verbatim transcript, but rather to capture the flavor of the viewer's reactions to the classroom. These perspectives were shared by Linda Hallenbeck, the classroom teacher; Dr. Carol Thornton, Distinguished Professor of Mathematics Education at Illinois State University; and the NCREL project team.

We suggest that you use this booklet as you view the video to add insight into the instructional methods used in the class.

Event 1	Day One. Linda talks about flipping a coin. As she demonstrates, she asks the students to guess what the ninth flip was and why.
Classroom Management	
Linda Hallenbeck	That verbal cue of mine, "Go," is just a management technique. I use it throughout the year. The children know they have to wait until they hear it to begin working. Sometimes I'll snap my finger, or something similar as a way of keeping students focused about going to work. It's a cue for them to just stand at ease until it's time to begin.
Teaching Strategies	
Linda Hallenbeck	I'm setting the children up for the idea of heads and tails being a 50/50 odds. As I'm flipping the coin, you notice that I've written on the overhead. I'm trying to model for the students. For some students who need organizational skills, writing on the overhead is a good way to model how they can organize their facts to later retrieve that information. I also refer to their journal writing and ask them to write down what they think and, more important, "why" they think it, which helps students organize their thoughts.
NCREL	In this event Linda does a really nice job of utilizing a problem context describing her own experience over the weekend when she was bored and flipping coins. So, rather than just say, "Here's an experiment," and jump right into it, she lays a problem context that they'll be interested in because it's about her. She further personalizes it by actually doing a think aloud. The think aloud isn't genuine, but it's nonetheless interesting. She does the think aloud suggesting that she's doing this experiment. She does a sequence of trials and keeps getting a certain outcome of heads. She's thinking aloud to herself, "Well, maybe there's a pattern here." She knows about the misconceptions students have about chance, and she knows that kids that age often don't understand the notion of chance and randomness. They're always thinking, "There must be some kind of pattern that's underlying this." So she's searching; she's suggesting that she sees a pattern there in order to activate their own conceptions about chance, which she'll probably be confronting later on with a variety of different discrepant events that challenge their current conceptions and move them towards a more sophisticated and accurate notion about chance and randomness. She gets them to challenge their current conception about chance by engaging them in a prediction exercise, which is really a good way to surface and critique people's conceptions about what they expect to happen and their hypothesis.

Event 1, cont.	Day One. Linda talks about flipping a coin. As she demonstrates, she asks the students to guess what the ninth flip was and why.
Assessment Carol Thornton	Before getting into a new topic, it is good to step back and pre-assess what knowledge or thinking students bring to a situation. Linda's ploy of having students log their initial thoughts into journals will be useful later on to help assess how their probabilistic thinking has matured.

Event 2

Students write down their guesses and reasons in their journals.

Teaching Strategies

Linda Hallenbeck

As the children are writing in their journals, my purpose is to circulate and view what they're writing. This encourages them to write more than just "heads" or "tails." By my peeking over their shoulders, I know that they're going to be writing more of the "why," thus causing the students to think more about the problem. I'm not passing judgment as I read. I'm just making sure that they've written an answer. I am also able to get a quick general assessment of various notions of the class' conceptions.

Carol Thornton

Probability is a relatively new topic for these students. Linda's strategy is to get students to "buy into the task" by making and sharing their predictions about a toss—whether it is heads or tails. Linda is setting the hook, so to speak, getting the students to make it "their" problem.

Assessment

NCREL

Linda is now very explicitly having them articulate their current conception of chance by surveying who thinks it's going to be heads, who thinks it's going to be tails, and who thinks that they shouldn't know or don't know. Then she has them writing down those reasons, which fits very well with the NCTM standards about communicating.

Event 3

Whole group: Students give reasons why they think the flip is going to be heads.

Teaching Strategies

Linda Hallenbeck

John does his best thinking aloud as he needs to "hear himself think." It's important to let children like John have time to talk, to gather their information. If you think about it, we as adults often need the same. I know I've gone to friends, told them my problems (as they listen quietly), and then thanked them for helping me solve my problems. They really "just" listened. The classroom teacher needs to be a great listener.

Carol Thornton

The teacher has made it clear that she is interested in their reasoning. She could have actively involved all the students before calling on individuals by asking them to explain their thinking to a partner. This teaching strategy, known as "think, pair, share" is a powerful form of cooperative learning that suits all ages: First reflect on what you think; next, pair up and share that thinking with someone else; and then offer to share your ideas with the larger group.

NCREL

Linda's teaching strategy here is to begin by posing an open-ended question, "Why do you think so, what is your reasoning?" Then she rephrases and summarizes their thinking, pulling out some of the vocabulary and the thinking patterns and strategies that they're using to make that particular statement or assumption. She's kind of scaffolding and is going to bring back their thinking in proving them incorrect or in formulating a new strategy or a new way of thinking, so she does a really nice job of rephrasing, questioning, summarizing, and using strategies that she can utilize later.

Problem Solving

Linda Hallenbeck

In this discussion, the children are really trying to bring out that "why." They're thinking whether it's heads or tails, and there's conflict in their minds of not being sure which it is. I think we also see evidence of the children wanting to be scientific. They ask, "Well, are you going to start at the exact spot?" They're trying to find patterns; they're trying to take the methods that we often use in science and apply it here. And that's really what all children want—to bring order to everything they do. They want to bring their conflict to rest, and so they're really struggling right now. This is a really important part of the lesson—to first create conflict, then for students to recognize the conflict so we can bring resolution to it later in the lesson or unit.

Event 3, cont.	Whole group: Students give reasons why they think the flip is going to be heads.
Assessment NCREL	The children are sharing some of their reasoning about chance, and you can see once again what their misconceptions are and that they really haven't internalized this notion of randomness. They keep expecting a pattern, so presumably there's some pattern of heads and they expect that to continue.

Event 4

Whole group: Students give reasons why they think the flip is going to be tails.

Problem Solving

Linda Hallenbeck

I love the way Angela referred back to the basketball article that we had discussed earlier. She's not sure what the coin toss is going to be. At this point, there are only a couple of students who are starting to look at the coin toss as being a matter of chance. The majority of them are still trying to find a relationship from previous experience. Research says the students' intuitive nature is to try to make sense of the mathematical concept of theoretical probability. Until the students are confronted with conflict, the problem will not be resolved. Angela sees the conflict and is trying to look at it more logically. Eventually, the goal is for all the children to look at the evidence rather than just previous experiences.

Carol Thornton

Taking a problem-solving approach to teaching, Linda has not intervened at this early stage to correct illogical thinking or misconceptions that have emerged in students' responses. In fact, she has deliberately invited contrasting views. The apparent conflict in thinking among students in the class sets the stage for the first probability experiment.

NCREL

Linda skillfully probed the boy's thinking and you learned about the sophistication of his thinking. He's seeing that there is a pattern, and he's trying to generate reasons why that pattern would occur. He's asking himself questions that reflect a pretty sophisticated level of understanding. He knows, for example, that you have to maintain the same conditions when you're doing this flipping. He's thinking that maybe the pattern is emerging because she's flipping it in a certain way to a certain height. Linda is doing a good job of helping him articulate what are actually sound reasons about why that pattern might occur, and his thinking is very scientific in nature.

Event 5 — Linda explains the flipping task and students get their materials.

Classroom Management

Carol Thornton

Note Linda's management strategy for making certain that all students understood the task: She asked students to restate the two big things she expected to see as they did the experiment. When directions and expectations are kept to a minimum and are clearly understood, students are in a better position to give full attention to the task at hand. Materials might sometimes be distributed in advance, but note how Linda avoided off-task play by withholding the quarters until they were needed. They were then distributed quickly enough by making this the responsibility of one student from each group.

Teaching Strategies

Linda Hallenbeck

It is important for the teacher to give clear expectations. The students knew exactly what I wanted to see in their journals. The "how" was their choice, thus forcing students to get together and discuss their ideas with each other. Students have to go through some problem-solving techniques in deciding how they are going to show the data, even though they know what data has to be shown. This event also shows that the students must clarify why they're doing what they are doing.

NCREL

In this event, Linda allowed some of the task to be controlled by decision making on the part of the students. They could actually decide how they were going to record and how they were going to conduct the experiment. She gave them some basic instructions, and again followed the standards, in that she wants them to communicate both in writing and verbally. She left it, however, very open ended as to how they were going to be involved in the strategies they would use for recording. Anybody who has worked with students' conceptions in math and science and wants to change them toward something more sophisticated knows how tenaciously students will hang on to their current conceptions and how difficult it is to have them restructure those conceptions. So doing their own experiment and their own investigation is a powerful way to do it. And to continue to push the notion of talking with your partner about what predictions you would make and the reasons for making the predictions will, again, keep on pushing their current conceptions of chance and randomness. A lot of times we don't see enough of that; it's so controlled and the decision making is on the part of the teacher. Allowing them to make these decisions will increase their problem-solving skills.

Event 6	Students work in groups as Linda circulates among them.
Teaching Strategies, cont.	
NCREL, cont.	In this event, Linda does a nice job of modeling facilitation—going between groups and asking probing questions, digging a little bit deeper into what they think and why they think it, gaining information about what they're finding in their small groups. Linda listens to students as they think and conveys that she's listening very attentively. She could try to ask fewer yes or no questions and rely more on open-ended ones. She did do a really nice job of facilitating, and there was real active involvement on the kids' part in discussing their thinking.
Problem Solving	
Linda Hallenbeck	In this event, Chris is really predicting that heads is going to come up because it's his lucky call. He has not made any reference to the fact that tails could come up (the 50/50 probability). He's recalling a soccer event where he's had heads luck before. Once again, here is an example of a child relating it to a prior event as opposed to using the logic of equal chance. Chris needs to find that although intuition is important, it's not exclusive.
Assessment	
Carol Thornton	Notice that the teacher spent just a short but very productive time with each group. Linda's basic strategy is questioning and listening to children's thinking, challenging that thinking, then leaving. This approach provides valuable insights for ongoing assessment of individual children. Some teachers carry a clipboard and peel-off labels with them during such times to make notes about individual students. Later they date and transfer the labels to students' files for subsequent conferences with the children or their parents. This approach also provides an opportunity for accommodating or challenging the thinking of individual students.
NCREL	It is especially interesting to listen to Linda's probing of the boy's reasoning about why he expected one outcome over another, and he talked about things like "his lucky number" and he's lucky about this or that. There are a lot of superstitions that surround games of chance, which is why we have successful lotteries in our culture. This really reflects conceptions he drew from the larger culture that are kind of shaping some misconceptions he has about chance and randomness and the superstitious beliefs that surround that.

Event 7	Group work continues as Linda asks probing questions.
Problem Solving	
Linda Hallenbeck	Mike's discussion about what happens on a baseball field versus what happens in a math class is consistent with the NCTM standards, which want children to see that math isn't just taught in the classroom. Math is real life, and what happens in the mathematics classroom and what happens on the baseball field are the same thing. They're not two different events. I think we could see him wrestling with that idea. He really started out very definitely, "Well, it's different in math class than on the baseball field," but through our discussion, he saw the relationship. "Well, no. I guess it's a chance on the baseball field, just as it is in math class." I think that was a really, really big leap for Mike. The logic applied in the classroom and in real life was a wonderful revelation for him. Although Mike isn't totally sure, he is beginning to question his prior notions—a first step in developing more sophisticated thinking.
Carol Thornton	Misconceptions in probabilistic thinking are best overcome when students explicitly and repeatedly confront their own ideas with experimental evidence. Linda is providing her students with one such opportunity in today's lesson. Because change in thinking is a process, not an event, we could expect that many similar experiences would be needed to help these students grow in their understanding of probability concepts.
NCREL	Linda does a beautiful job here of getting the boy to think about the connections between math and real-life experiences and really probing the kind of conflict that evidently exists between the things that he would expect in math and the things that he would expect in real life. On the one hand, the boy is saying, "Well, it's really just chance, and so you really can't say. Any guess is just as good as any other guess." But on the other hand, he sort of expects there to be a sequence, so he expects it to be tails because the last flips have been tails. So you can see he's really struggling with that and in the end, Linda leaves him just feeling that discomfort and feeling that dissonance, and saying to him, "Well, just think further about it." Linda also helps him to think about the extent to which mathematics has power in terms of providing him with concepts that he can use to think about everyday real-life situations.

Event 8 — Linda talks to one group about their work.

Teaching Strategies

Carol Thornton

These students have very naive, underdeveloped notions of probability. They do not yet understand that while unusual events like tossing many consecutive heads can happen, in the long run, the results will be about as many heads as tails when a fair coin is used. The development of probabilistic thinking is more a matter of experience than age, for many adults have shown the same naivete. The teacher's strategy is not to "tell" students about the "law of large numbers" for a coin toss; that is, about what typically happens when a coin is tossed many times. She rather is giving them the opportunity to construct their own understanding by encouraging them to reflect on the evidence confronting them.

NCREL

Here you see it beautifully demonstrated how there was a discrepant event generated that challenges their current conception about there being a pattern here. Linda really seizes the opportunity to push that discrepant event so that eventually they begin rethinking their conceptions. She demonstrates real patience here that you don't see very often. Most of us, as teachers, would just give up after a while and say, "Well, listen this is the way it is." But she resists doing that, and she let's them think through the concept and construct this idea of what chance and randomness mean.

One of the NCTM standards looks at patterning, and so lessons like this are really excellent in that not only are they pointing out concepts related to randomness and chance, but they are helping kids realize the differences that exist within mathematics. There is not always an exactness; there is not just one right answer. Linda not only models this acceptance and discovery, but she models some real analysis of the definition of mathematics.

Problem Solving

Linda Hallenbeck

Jordan is really starting to look at the idea of clusters or runs, but in his mind he is still looking at a pattern. This is consistent with what we've seen in the classroom to this point. Children are really trying to focus on the idea that with heads and tails there is a pattern as opposed to a randomness.

Event 9	Wrap-up of day. Linda gives thinking assignment for homework.
Classroom Management	
Linda Hallenbeck	When our day is almost at an end, I periodically use a technique of singing "ta-ta-ta-tum" to get the children's attention so that I can stop and give directions to all students. I like to try to wait until I think I have the attention of 99 percent of the students. One boy was starting to leave before I was done talking and I called out his name. I didn't want to make an issue out of it, yet I wanted him to realize I wasn't done.
Carol Thornton	The teacher's remark, "I'll wait until I know you're not moving" was an effective management strategy for gaining everyone's attention for the lesson wrap-up.
Teaching Strategies	
Linda Hallenbeck	I tried to review the idea of what we had done to that point and to outline our next day when we would be looking at the spinning. I asked a student to restate that problem. It is a helpful technique for me because a student expresses it in his or her own words, and another student might interpret it better and clarify it. It also helps to review for the children so that when they walk in the next day, there's no disorientation because they know what to expect.
Carol Thornton	In these final moments, Linda suggested that students "look back" or reflect on the experiment they had just done and also "look ahead" to the next day's lesson. In looking back, she voiced her expectation that students should independently conclude their experiment and be prepared to describe their results the next day. Hers is a powerful "explore, reflect, discuss" approach to experimental probability. To assure that students are clear about their preparation for the next class, Linda asks a student to reiterate the homework assignment.
NCREL	The developmental sequence is excellent, thinking about the heads and tails and then going into the spinners and so forth with the emphasis on thinking. Linda said, "You know, I really won't know if you do it until you come in and are able to talk about your thinking." She could have used a metacognitive tool, either a thinking log that has open-ended questions—with a question that extends into the prediction—or possibly just journaling. The best time to capture their thinking would be right now, but because of those class periods, she had to end. If they were to even be exposed to a couple of questions and jot some thoughts down and then take it home and further develop their thinking log, it would be great, but what happens is you run out of time and

Event 9, cont.	Wrap-up of day. Linda gives thinking assignment for homework.
Teaching Strategies, cont.	
NCREL, cont.	there's really no time for debriefing. It's great to debrief, even if it's just for two to three minutes. But this event shows a super excellent emphasis on thinking. One thing to note here is whenever you give an oral assignment like that, you are relying a lot on auditory skills. Many students have a tough time with auditory directions. Both auditory and something in writing would really help. It might be a nice follow-up activity to have them interview their parents. Maybe she wants them to really rely only on themselves for right now. But it would be interesting to do an interview with parents about their beliefs about probability, especially given the popularity of things like the lottery and gambling. When you look at the mathematical illiteracy that exists among the general populace, you find that the sorts of misconceptions that we're seeing here are really shared more widely. So it might be an interesting way to begin engaging family discussions around this and engaging parents in thinking with their child around the issues of chance and randomness.
Problem Solving	
NCREL	Linda puts such great emphasis on thinking, and she really validates the importance of thinking by saying, "This is what we'll be doing, and I want you to spend some time tonight thinking about what you did today and its significance. Ask yourself questions about whether you noticed anything about heads and tails in terms of patterns." Then she offers a way to extend and hopefully deepen their concepts about randomness by looking at a spinner, which instead of having just two outcomes to every event, will have four different possible outcomes.
Assessment	
Linda Hallenbeck	The children are dispersing to wherever they need to go. Some of them stay for science, others go off to social studies class. It's an exciting time in some ways in that you hear children talking with each other about what their theory is or what they believe. Other children come up to you and talk to you about what they believe; however, even more exciting is when you hear one child say to another, "I'll talk to you in social studies class about it." You know you've taken mathematics outside the "math classroom;" that has to be one of the most exciting things about being a teacher of mathematics!!

Event 10

Day Two. Whole group: Linda asks students what they discovered yesterday. They discuss the word "random."

Teaching Strategies

Carol Thornton

Linda has chosen to listen to student summaries of their heads-tails experiment. An alternative and very useful strategy is to have each group record the number of heads and the number of tails obtained on a class chart, and then compare their results with that found by totaling the pooled data. Unusual patterns stemming from smaller numbers of trials often even out when pooled so that outcomes approach what might theoretically be expected. This strategy of pooling results and reflecting on patterns in the pooled data in relation to individual work is a very effective way of helping students overcome misconceptions.

The idea of a "random" draw was also discussed in this lesson opener. Note how Linda elicited both examples and non-examples of the new concept.

NCREL

One of the nice things that Linda does is link the various students' examples. She asks students to compare them and to integrate what they found in the different groups. And she does that very effectively by having them actually compare whether they would come up with the same results, and by really moving them to making some generalizations. She also used the word "feelings." "What are your feelings about that?" So it wasn't just the cognitive, but what are some of the real gut feelings related to their generalizations. It's not just analytical at this point because she's integrating feelings. It's like the way that people think about gambling. There are hunches, there are feelings, and there is a sense of randomness. So she's integrating a different kind of dimension in there, more of an emotional dimension.

Problem Solving

NCREL

In this event, you can see how tenaciously the students are holding on to the idea that, indeed, there is a pattern. To them, what would account for the pattern is maybe how the event is generated itself, the nature of the flipping, maybe the force used with the flipping and the height it goes, or whether you begin with a heads or a tails. So you still see them struggling with that and still thinking that there must be some kind of pattern.

Event 10, cont.	Day Two. Whole group: Linda asks students what they discovered yesterday. They discuss the word "random."
Assessment	
Linda Hallenbeck	I like to start off with a quick review of yesterday's lesson. The students' heads and tails theories are really still based on the idea of patterning, and that's something we'll continue to work on as the unit unfolds. The next thing that we discussed was the idea of randomness and although we talked about random order all year long—I started in August and now it is May—they still don't have a thorough understanding of randomness. When Drew started to talk about what he thought random was, he gave a wonderful definition, but when he started to apply it, he was having problems talking about the alphabetical order. He corrected himself, but went on again to say, "No, ABC order is correct." I was going to ask him a question about what made it random, and in that short little time period he had for reflection, he realized, "Wait a minute, alphabetical would not be random. In fact, it would be the opposite of random." I still wasn't sure then that the entire class had a feeling of randomness, so that's when I went on and talked about the idea of what would make it random and what wouldn't make it random. Drew's dialog is significant for many reasons. It shows the power of thinking aloud and also his comfort in being able to change his thinking in a classroom atmosphere of mutual respect. Drew's reflections caused changes in his thinking.
NCREL	During this event, you can see that they are getting to the point where they are ready to self-correct on their beliefs. When the boy says that it is like being alphabetical, he later changes his mind and says that alphabetical is not random. So we are beginning to see the hesitancy that reflects they're beginning to break down that old conception. What might facilitate that is if they use a representation in recording their thinking as it occurs. Linda could use a data collection system at this point to monitor their thinking, such as a diagram or just writing it down on the overhead as a summary of their thinking and generalizations.

Event 11	Whole group: Linda asks students if they know for sure what would come up if she randomly picks a coin.
Teaching Strategies	
Linda Hallenbeck	The last part of this shows the planting of an idea about how many choices they have. This is a significant thing to point out (that in heads and tails, you only have those two choices). When we build on the flips, then to the spinners, our number of choices increases, thus we have more of a distribution. So the notions of "Well, how many choices do I have?," "it's an equal thing," "so I have a 50/50 chance" are all planted so the students begin to think about it as we move on with the lesson.
Carol Thornton	Again the teacher has introduced dissonance by inviting opposing views. Linda also has made it clear to students that she is interested in the reasons for their predictions. Clearly she has invited their "ownership," their vested interest in the outcome—an approach that eventually will help them clarify their own misconceptions.
Problem Solving	
Linda Hallenbeck	In Angela's discussion, she refers to her previous results in coin flipping. Children like to refer to other incidents of what they know is a certain for uncertain situations. That's a concept that obviously has to be developed during this time in the probability unit. The other thing that Angela started to allude to was the coin weighting idea—that the heads side or tails side, depending on which student you talked to, is a little heavier. Therefore, according to their theory, it's either going to be weighted down or lighter. To avoid that, you could use a poker chip and mark it with an "H" or a "T." I chose not to because I didn't want to focus on that idea, and I wanted to use real coins for the real-life situation.
Assessment	
Linda Hallenbeck	I counted the hands of how many students thought heads or how many students thought tails and how many weren't sure. That's just a quick assessment for me to get an idea of their thinking. I would have been surprised if no one thought there was an equal chance of it being either one, heads or tails, because by this point I expected that some children would begin to see that they have no way of knowing. It is important also to see that there were still many children, as would be expected, who thought that it was either going to be heads or tails from previous knowledge.

Event 11, cont.	Whole group: Linda asks students if they know for sure what would come up if she randomly picks a coin.
Assessment, cont.	
NCREL	In this event Linda did a really nice job of effective questioning and active listening. She also paced the lesson to allow for wait time, and she asked students for altering points of view. Linda posed the question, "Why do you think so?" So she asked them for justification for their ideas. This was a really good informal means of assessing their thinking and their knowledge about chance and randomness.

Event 12	Whole group: Linda flips a coin and gets tails. She asks students what her next toss will be and why they think that.
Teaching Strategies	
Linda Hallenbeck	I think it's really significant when Ben changes his mind. He started to talk about heads versus tails, and as he heard himself think, he realized, "Well, wait a minute. That doesn't make sense. I don't know. It could be either one." That is a powerful thing for children—to be able to have that freedom to talk about it and to openly say, "No, I think I do want to change my mind." Another good method for that is for you to say, "Take a minute. Talk to your partner about it and then give me an answer." That's another way for every child in the classroom to hear him- or herself think, and possibly work through a problem to come up with a solution.
Problem Solving	
Carol Thornton	Children are in a state of flux at this point. Predictions are made and revised quite rapidly. Some children are predicting the toss could go either way, but believe the result to be a function of whether the coin was heads up or down at the start. The teacher's strategy is to get student thinking out in the open so it can be used as a stepping-stone to further thinking and reflection. By always expecting a reason for statements made and by eliciting different responses, the students are continually forced to reflect—and this is necessary for any change or growth in thinking.
NCREL	Linda's modeling of an experiment was really nice. As she demonstrates the experiment, she continues to ask good questions and models problem solving. The coin flipping doesn't have a real-life context, but it is nevertheless kind of a puzzle. The class is actively involved in trying to figure out and give meaning to the whole concept of chance.

Event 13	Whole group: Linda asks students to predict her next flip. Students explain their reasoning.
Classroom Management	
NCREL	In terms of her whole class setup, she has the students seated face to face, so that even though she has a lot of students in her classroom, they're at least able to see about a third of the other students. In this way, they can practice having active listening and eye contact with students around them.
Teaching Strategies	
NCREL	At this point, Linda could have done some small group activity with students posing the questions rather than her. She could, however, pose some questions that would help students go deeper into their rationale. In facilitating the classroom discussion, she could do more with linking one student's idea with another student's.
Problem Solving	
Linda Hallenbeck	This event continues with the idea of looking at one side of the coin being more weighted, the opposite of what Angela thought. John still didn't have the idea of how that weight would fit into the situation: "If it would really come up when I flip it over in my hand, then does that mean that the lighter side or the heavier side would show?" It seems that John needs to verbalize and work through things. It's interesting that, based on previous knowledge, they were all looking at the idea of tails coming up. They had changed their minds as just a little before, the majority of the students (almost two-thirds of them) thought it could be either one. Now, based on what's been happening, they're coming back to that tails theory. Maybe logically they are thinking about having a 50/50 chance, but they're still wrestling with the idea. Probability research with college students showed similarities. The college students said, "Heads came up the first time. I know it's a 50/50 thing, but because heads came up the first time, I really in my heart believe heads should come up more often." That's the argument with which a child has to wrestle—the difference of what is logical and what's in their heart. Reading the research helped me first be aware of what to expect my fifth graders to think, and then how to deal with their notions and not to force their thinking.
Carol Thornton	Closure will eventually be provided, but Linda does not rush at this time to affirm or question what students believe. Hers is the problem-solving approach of providing significant tasks and questions with the expectation that students themselves will work things out.

Event 13, cont.	Whole group: Linda asks students to predict her next flip. Students explain their reasoning.
Assessment	
Carol Thornton	Students' thinking that underlies their responses to teacher questions is an opportunity for ongoing assessment and teacher decision making during instruction. Teachers who are sensitive to that thinking and flexible enough to shift from or modify their agenda to accommodate that thinking make a greater impact on nurturing and extending students' understanding in mathematics.
NCREL	One of the nice things about Linda's work with facilitating student thinking here is that she accepts a variety of responses from students. If a response is not really a correct response in terms of the student's knowledge of chance, she doesn't evaluate his/her response or put his/her solution down in any way, not in tone, not in facial expression.

Event 14	Whole group: Transition to using spinners instead of coins. She asks students to predict what number it will land on when she spins.
Classroom Management	
Linda Hallenbeck	Here, one student stopped and said something to me and, based on time, I had to make the decision to move on to keep the lesson going. I tried to politely say to the child, "Thanks, but no thanks. Let's move on with our lesson for the day." Also, when the children wrote in their journal as to what they thought would come up on the spinner and why, I allowed about three minutes or so, which was long enough for me to circulate to make sure that they had each written a number, and then, more importantly, that they had each written a "why." That, again, confirms for the children that I do expect something to be written and that I'm going to be spot-checking. This forces the students to think, reflect, and express their ideas. Later, I'll read it carefully to give them written feedback.
Teaching Strategies	
Linda Hallenbeck	I didn't do any wrap-up to the coin toss exercise because we still needed to make some kind of correlation between flipping the coin and the spinning. I'm trying to look at the idea of a 50 percent chance with the coin toss versus a 25 percent chance on their spinners, but I'm not quite ready to zero in on that. Thus, there were no conclusions drawn before moving on to the spinners.
Carol Thornton	Students become "good" at what they are given opportunity to practice. In this class, the expectation is that students' statements should be grounded in reasoning. The strategy in this case is to WRITE the prediction and its reason. As visual learners, some students internalize or reflect better upon what they see. Writing provides a useful break to oral discussion, builds in individual accountability, and provides a document that can later be refined or referred to by either teacher or students. The teacher's strategy is to move about and look at different predictions and reasons, not to use the time for some peripheral task.
NCREL	It's kind of interesting the way that this lesson starts off, because Linda does give them a little bit of information that they're going to be working with a spinner with numbers one through four. She doesn't ever show the spinner, and the students don't ever ask to see the spinner, and, in fact, at this point the spinner could have unequal parts.

Event 14, cont.	Whole group: Transition to using spinners instead of coins. She asks students to predict what number it will land on when she spins.
Assessment	
Linda Hallenbeck	The children are writing in their journals and reflecting on their ideas. I would hope some would reason, "Well, I knew in the coin toss it could be either one, so in the spinning it could be any number." I'm looking at their reasoning for "why" they chose a specific number.
NCREL	In this segment, when Linda asks the students to choose a number that they think will come up on the spinner and describe why, she used writing to have them individually reflect. At this point, she really is getting more involvement and participation on all the students' part by not posing questions to the whole group and just having one or two answer.

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Event 15

Whole group: Linda asks students to predict what she will get when she spins a spinner at the overhead. Afterwards, she reveals an unequally divided spinner.

Teaching Strategies

Linda Hallenbeck

It was, I admit, a setup. (Students need to see non-examples also.) Children usually don't choose the number one, so when I did spin, the odds were certainly with me that I was going to get the number one, and that was what I was counting on. If I didn't get the number one, I probably would have said, "Oops! I slipped," and do it another time. The truly wonderful part was when Jordan wanted to do it again, and again, and again, and again, up to the point that he did it six times (to "spend" an equivalence of his school lunch of $1.50). In his heart, he just felt that he was going to win. He knew the odds were against him, but yet he just knew at some point he was going to win, and he wanted that feeling of winning, so he went for it. After viewing the tape, I thought it would have been interesting to ask each student why they didn't choose the number one. This was also a very subtle planting of an idea for later discussion. The unfair spinner was divided in 32nds. Thus, numbers two, three, and four each had only one chance in 32. I had, with the one, 29 chances in 32. The probabilistic logic of the number of choices relates to the probability factor. I also tried to tie it back to the marble chance in the NBA lottery to give the students more to think about.

NCREL

Linda kind of sets the group up in a way for a surprise because of the fact that she's hiding the spinner. It catches them in a pretty common error of assuming that the spinner is going to be in equal parts. Another way of handling this rather than doing it whole group is to give the results of spins from a variety of kinds of spinners and to ask the students to try to determine why there's such variation. It's interesting, though, because creating some frustration will in fact make it a more memorable experience for the students. They'll remember the day that they were kind of set up. Some teachers do this, and they do it effectively so that students enjoy the fact that they've been involved in a trick.

Problem Solving

Linda Hallenbeck

The children are still choosing numbers because it's their lucky number, or it's their favorite, or it's the highest number; but to them it's a good, logical reason. Children want to bring logic to their world. They need to build a more sophisticated logic system based on facts. That's part of what math does for us. It brings order to our world.

Event 15, cont.	Whole group: Linda asks students to predict what she will get when she spins a spinner at the overhead. Afterwards, she reveals an unequally divided spinner.
Problem Solving, cont.	
Carol Thornton	The teacher dramatically introduced a novel problem—a spinner that was not evenly divided. This "problem" effectively forced students to consider the notion of equally likely outcomes and the likelihood of winning when the odds are not in your favor.

Event 16

Whole group: Students discuss the "unfairness" of Linda's spinner. She relates a newspaper article about the basketball lottery that they read in the past.

Teaching Strategies

Linda Hallenbeck

After we did the spin and we talked about "perhaps" my unfairness, their response was, "Can we do it with real spinners?" What a wonderful thing, that they're begging to do the mathematics, to keep those records, because they know that's part of it. That's a wonderful feeling as a classroom teacher—knowing that they are going to get to the point that they are part of the mathematics as opposed to the teacher being the director and the students merely taking orders. Since they're involved, they're going to be constructing their own knowledge and forming their own opinions. This segment tied into the original newspaper article we had read earlier, where their chances of getting a two, three, or four on the spinner were about as likely as Orlando getting their number to come out to get the low pick. We started to look at that fairness issue. Is it as fair for me as it was for them? Those are all issues involved in probability and chance—important issues that in a fun way we can begin to examine. They're not going to forget that spinner and that number one, as they are going to think about fairness and probability.

NCREL

In this event, Linda makes a nice link to a real-life situation from a newspaper article. She could have made it more interactive at this point by asking them what they recall from the article.

Problem Solving

Carol Thornton

An important hallmark of growth in probabilistic thinking is the ability to use numbers to describe chance. Figuring out that students selecting a two, three, or four had only one chance out of 32 to win is a purposeful move to quantify thinking in chance situations.

Event 17 — Linda assigns spinner task.

Classroom Management

Linda Hallenbeck

Here the children were involved in decision making regarding which other team of two they wanted to join. I think they did a nice job of quickly getting into their groups, assimilating from teams of two into teams of four. I gave them the prerogative of choosing their own group because the twosome I wanted them with was already determined, so it really didn't matter what the foursome was. I hope the politeness came through, their mutual respect. I try very hard to ask them in nice ways to do things, as opposed to being so directive, and I expect the same of them in their group work.

NCREL

When Linda sends them into small groups, you can tell that they've done this before. She has really organized the management and they're ready now to go on to the next activity.

Teaching Strategies

NCREL

Linda makes a nice link to the previous day's lesson where she's asking them to continue to use tally marks, and she also asks a really nice question about the difference between tally marks for the coin toss activity and the number of columns for the tally marks for the spinner activity.

Problem Solving

Linda Hallenbeck

The students had to decide how they were going to set up the logistics of their logs as well as their group work. One thing that I wanted them to realize was that their notes would look different this time. Rather than having two columns—that is, a heads and a tails tally column—they would have to have four. I was hoping that they would begin looking at the idea that they were going to have to distribute those 25 spins over four numbers, and, therefore, they're probably not going to have as many spins in any one category as they did in the heads and tails. They have four chances as opposed to two chances.

Carol Thornton

With the unevenly divided spinner, most students had only a 1/32 chance of winning. As a direct follow-up, Linda distributes spinners evenly partitioned by color into fourths and presents a problem to guide their thinking as they experiment: Out of 25 spins, what predictions might logically be associated with each of the four colors? Very subtly, the teacher is inviting students to grow, to quantify their thinking.

Event 18	Small group work: Linda circulates among them as they predict and spin.
Classroom Management	
Linda Hallenbeck	The children broke into their small group work activity, and they were very task oriented. I didn't have to worry about them not being on task because they were excited about the task.
Teaching Strategies	
Linda Hallenbeck	While they were working on their task—and that was actually about a 20-minute time span—my job as a teacher was to circulate to the different groups and facilitate by asking probing questions that forced the children to reflect and refine their thinking. I would ask a group for their specific findings. I might ask them to talk about the distribution, how their spinning compared, or how the spinning with four numbers compared with their heads and tails work with two possible outcomes. I might ask them to relate it back to the luck work they completed and, again, probe about luck versus chance or patterns. All year we've worked with patterns in mathematics. Now we're really looking at something that doesn't have a pattern, something that is random. It's something that's very difficult for them to break away from, and my task, then, is to have them start thinking about whether all things in life have to have patterns. In the discussion with Erin and Matt, I was trying to elicit from them that this might be one of those times that we might have to accept the fact that we're not going to be able to find a pattern. Other groups did talk about patterning, but there were other findings also—that idea again of luck, relating the coin toss to the spin, and the distribution of numbers. This is a very important time in the lesson. It's pushing the students' thinking sophistication to the next level in terms they understand.
Carol Thornton	It is very easy to take a break while students are busy with group work. Instead, Linda takes advantage of the teachable moments this opportunity offers. Moving between groups, she asks questions to challenge and extend student thinking. She encourages students to use the language of probability as they discuss.
Assessment	
Carol Thornton	Moving between groups provides Linda further opportunity for ongoing assessment of individual students and valuable information for on-the-spot planning and decision making.

Event 18, cont.	Small group work: Linda circulates among them as they predict and spin.
Assessment, cont.	
NCREL	In this segment, Linda is asking them to experiment. She's facilitating by wandering around in between the groups, posing some questions, trying to dive into their thinking a little bit more. She poses a number of questions with each group, does a nice job of summarizing some of their thinking, and checks to see whether or not their thinking is consistent. She is trying to catch them in some of their misconceptions, but not being too direct about that. She could ask them why they feel that it's that way, or what do they think about this, or how is what they think different than what someone else in the group thinks. This would make the questions a bit less directive.

Event 19

Whole group: Linda asks students to compare the coin tossing activity to the spinner activity.

Classroom Management

Linda Hallenbeck

Although the children weren't eager to come back to their seats, they knew we needed to move on with our large group discussion. In pulling them back, I tried to give them enough time to gather their final thoughts in their groups before we began our class discussion. When there are still a few students lagging behind, I try to praise those students who are already back, letting the others know that we are waiting for them.

Teaching Strategies

NCREL

This is a pull back to the whole group where Linda helps them summarize and do some generalizing. She asks them to compare the coin flipping activity with the spinners activity, and she nicely summarizes what students think and rephrases their points of view. At one point, she asks how that's different than another activity and digs a little bit deeper. She goes back to the whole group to ask another student to confirm what one boy has said, so she's testing within the group. She probably thought that there might have been some disagreement within the group. That might have been good to pull out in small group rather than bring back to the whole group, but she may not have had the chance to do that with all the running around between groups that she had. It was good to confirm within a group that there was agreement.

Problem Solving

Linda Hallenbeck

The children had to go back and look at their data and reflect on their thinking. They had to go back and review in their journals to compare two different sets of information that they had collected—the heads and tails and the spinner work. My objective was to try to get them to see how the outcomes of the coin tossing and the spinning activity were both based on odds. I still had to deal with some of their misconceptions. When Matt said that both things were round, but then added that the coin only had two sides, I was really pleased as that showed such progress for him as an individual. I like to ask if someone could restate a student's idea, only using his or her own words. It's a wonderful technique because one student is synthesizing, and Matt, for instance, gets to hear someone else express his ideas.

Event 19, cont.	Whole group: Linda asks students to compare the coin tossing activity to the spinner activity.
Problem Solving, cont.	
Linda Hallenbeck, cont.	When Matt said the number four came up more often because it was the highest and the other students agreed, it demonstrated that their thinking cannot be swayed very easily. Again, the sophistication of probabilistic thinking of the students will increase as their challenges and experiences increase.
Assessment	
Carol Thornton	By asking students to compare the spinner and heads-tails experiments, Linda is planting the seed for making generalizations about probability situations that, theoretically, have equally likely outcomes. Children such as Matt, who believe that four comes up most often "because it is the largest number" are not ready for this generalization. They will require further experimentation and whole-class discussion and comparison of results.

Event 20

Whole group: Linda asks students to predict what would come up if she threw a die.

Teaching Strategies

Linda Hallenbeck

In reading much research literature before I began this unit and trying to decide what to put where, I purposely started with just the idea of a coin toss because there are only two chances involved. The logical progression was to move to four choices, and then to six choices. However, more and more conflict was created as we went along. Yet the students could take something they had learned from the first and try to apply it to the second activity of spinning. Having the students actually doing the flipping and spinning tasks, allows them to clear up their own misconceptions of luck, favorites, and such. And when they clear up their own problems, it becomes their learning. The research I read prior to organizing and teaching the unit gave me an understanding of how students are thinking about probability. This knowledge allowed me to initiate conversation with students to challenge their intuitive misconceptions to more sophisticated thinking of probabilistic concepts.

Carol Thornton

The strategy of creating a chalkboard list of results from all teams might have been useful to Matt and other students who believe that "larger numbers come up more often." Seeing a visual record that different numbers "win" a spin more frequently often triggers reflection that oral discussion cannot produce. Comparing the results of one team with the pooled results of the entire class may stimulate the further discovery that when a spinner is equally divided, the results for each color are "close," and this idea also applies to the dice experiment Linda described.

Event 20, cont.	Whole group: Linda asks students to predict what would come up if she threw a die.
Problem Solving	
Linda Hallenbeck	This is a wonderful segment where John comes up with the idea of changing the numbers to different colors. Since they thought four came up more often, and if we looked at that four as being blue, blue would come up more often. That really was a wonderful way for John to present that idea. It created a lot of conflict for the children, and they had to stop and rethink the logic of their earlier answer. It really made them think about the problem and try to figure out what was going to happen. They were sure that the larger number would come up more often. Thus, when I rolled the die, I thought six would be their answer, but they gave me many different answers. It is interesting, though, to look at their reasons. A couple of the students said, "You have more choices, so you're going to hear more answers." That's real progress if we look back from the first day to now—that there are more choices, more answers, and more possibilities with four than with two, and now when we roll a die, we're going to have even a greater number of answers. And so for them to have made those leaps was wonderful. However, I want that little bit of conflict to be in their minds for our lesson tomorrow. Tonight they're in that moping and groping stage: creating conflict in their minds until there's something that doesn't rest easy with them. So for them to put their mathematical life in order, we have to find that conflict. They have found conflict with this question: Should six come up because it's the larger number or should a different number come up for a different reason, or do we know what number will be rolled?
Assessment	
NCREL	In this group, one of the boys, John, contributes a very different perspective and a different point of view. You can tell that Linda has set up the classroom climate so that it's very much a risk-free environment and the students feel very comfortable with chiming in saying, "Oh, I think about this differently." She does a nice job of piggybacking on his idea, extending his idea by posing a question relative to the use of a die and how that might be different. She does this to check their thinking and to check to see how they're generalizing and creating rules. She used her own confusion about their responses to help challenge some of their thinking about some of the misconceptions, and left it that she's the one who's confused rather than they.

Event 21

Whole group wrap-up: Linda tells them that tomorrow they will try the die, and then compare the coin tossing, the spinning, and the die throwing.

Teaching Strategies

Linda Hallenbeck

I was really trying to give them some direction in what was going to be happening next. We didn't hit upon that idea of the 50 percent, 25 percent, 16 percent yet, but that, again, will come as we go on with this unit. Most important in this segment was for them to pull the ideas together to bring closure. They are building a scaffolding for more sophisticated probabilistic thinking.

Carol Thornton

At lesson wrap-up, Linda again gets students to "look back" on the lesson in which many different beliefs emerged and also to "look ahead" to the next lesson where those differences will be addressed. She also gets students themselves to articulate the movement from two, to four, to six choices in the coin, the spinner, and the die experiments. Conceptually these experiments share the common idea that all choices each time are equally likely. By linking them in lesson wrap-up, some students may begin to consider this idea.

NCREL

At the beginning of this event, Linda is really comforting as she says that it's okay to have conflict because it really does challenge your thinking a little bit.

Problem Solving

Linda Hallenbeck

We had some closure to the two days of activities. They've been sifting a lot of ideas around. I want them to start categorizing their thinking. Kim was very succinct, I think, in putting it together. She talked about the idea of two, four, and six and the logical sequencing of putting those together. The chances decreased as the number of possibilities increased, and in each activity we did, the number of choices increased.

Assessment

NCREL

Linda makes a nice link back to the coin tossing, the spinners, and then the die, and she poses the question as to why they think that she created this sequence. The student does a good job of describing her thinking.

Event 22

Whole group: Linda assigns thinking homework about predicting the die throw and then dismisses them.

Teaching Strategies

Linda Hallenbeck

In this part of the lesson, I was really trying to give them some thoughts for tomorrow. Maybe later in the day they might say, "I think you're going to get a number one, Mrs. Hallenbeck and win," or "I think Mr. Haines is going to be able to knock you out. He has a better chance because... ." It's just wonderful to know that during the day the students are going to be talking about mathematics and they're going to be thinking about probability. I try to give them a problem that I know will elicit discussion during the day. Mr. Haines is my partner teacher, and the students have a great deal of respect for him. We have fun in school. (We work hard, but we have fun.) I know they're going to talk about probability during the day, and that was really the purpose of that segment—to have them thinking about mathematics throughout the day and maybe even have a discussion around the dinner table tonight.

Carol Thornton

The "thought for tomorrow" idea and its "why" combine to form a powerful end-of-lesson strategy. Two probability notions are central in the thought or problem Linda poses about whether a "one" would come up on the next toss: the notions of chance events and equally likely possibilities. The seed is sown for nurturing probabilistic thinking for those who are ready—and certainly for the next class.

NCREL

In this final event, Linda leaves them with a thought for the next day by linking it back to a real-life situation, that being the game of Aggravation®. She sets it up so that she and another teacher in this hypothetical situation are playing Aggravation®. In this way they can put themselves in this game context in order to think about Linda's chances of coming up with the number one on a die that's labeled one through six. Another possibility is to have the students involved in the gaming situation by setting up the scenario so that it is a game between students.

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