Eliciting Elementary School Students’ Informal Inferential Reasoning through Storytelling

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ELICITING ELEMENTARY SCHOOL STUDENTS' INFORMAL INFERENTIAL REASONING THROUGH STORYTELLING

by

Dustin Owen Smith

A dissertation submitted to the Graduate College in partial fulfillment of the requirements for the degree of Doctor of Philosophy Mathematics Education Western Michigan University August 2014

Doctoral Committee:

Kate Kline, Ph.D., Chair Jane-Jane Lo, Ph.D. Ok-Kyeong Kim, Ph.D. Carol Crumbaugh, Ph.D.
One growing area of research on statistical learning is Informal Inferential Reasoning (IIR). Makar and Rubin (2009) describe IIR as having three components: making and evaluating inferential claims, supporting claims explicitly with data, and attending to the inherent uncertainty present in statistical inference-making. This dissertation study was built around developing a method for providing opportunities for elementary school students (Grades K, 2, and 4) to engage with IIR within the context of stories and storytelling through a method called Storytelling-Questioning. After interacting with and discussing two separate stories, it was found that students of each grade level were able to engage in IIR through this method although magical contexts and accessibility of data in the stories were important constraining factors. Overall, while students were able to engage with IIR, they struggled to identify relevant data and to support their claims about uncertainty.

This study contributes to the description of the IIR abilities of elementary school students. It also provides the foundation for enhancing a common pedagogical approach used by elementary school teachers, reading stories, in a new and practical way in order to engage young children with statistical ideas.
ACKNOWLEDGEMENTS

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Finally and most importantly, thank you to my advisor Dr. Kate Kline. It wasn’t an easy process and I know at times working with me was frustrating but I sincerely know that you challenged me, advised me, focused me, and were honest with me in a way that worked. I’m a better writer and math educator for your efforts. I’m thankful to have had the chance to work with you.

Dustin Owen Smith
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INTRODUCTION

Introduction to IIR

Statistics education must occupy a prominent position in the school mathematics curriculum. Navigating, understanding, communicating, and persuading in modern society requires statistical knowledge. Within society, people can be found making arguments based on data and utilizing statistics in politics, in health research, in scientific findings, in business, and in day to day conversations. These are only a few of the numerous instances of the use of statistics in society. Data-based messages and arguments are prevalent and varied in their source. People encounter statistics coming from media such as newspapers and TV news, from scientific research, and from family and friends. With all of this statistical information saturating our lives, it is not hard to see the value that being statistically literate would have in our modern society.

The importance of developing statistical literacy in schools is advocated by numerous researchers (Shaughnessy, 2007; English, 2012; Pfannkuch, 2012; Gil & Ben-Zvi, 2011; Gal, 2003). The societal practicality of students leaving high school with the ability to think and reason statistically is at the center of these researchers’ calls for improving statistical literacy. These calls are echoed by organizations such as the American Statistical Association, through documents like the Guidelines for Assessment and Instruction in Statistics Education (GAISE) (Franklin et al., 2005). GAISE not only establishes the importance of statistical literacy, but also makes claims about how this should be achieved. GAISE recommends that statistics for grades K-12 be viewed as an investigative process done within the complexities of a real-world situation. In order to
understand how to implement this type of statistics education, using research to further our understanding of how students think and reason statistically is critically valuable.

**IIR and Approaches to Data**

Informal Inferential Reasoning (IIR) is one type of statistical reasoning that is purported to increase students’ ability to think critically about statistical information. IIR is a specific type of data-based predictive reasoning. As it is a relatively recent construct, it has several definitions. One such definition provided by Makar and Rubin (2009) summarizes IIR with the following three components:

1) Statements that articulate uncertainty
2) Statements that make or evaluate a claim that goes beyond the sample data
3) Statements that contain references to data the inferences are built upon

As the name suggests, this type of reasoning is informal (as opposed to formal) in the sense that the issues of statistical concern are not necessarily on formulas, computations, or tests of statistical significance, but rather on utilizing appropriate data-based thinking and reasoning.

Recent research related to IIR has made two major contributions. The first involved elaborating on IIR as a conceptual component of statistical thinking and the second was providing concrete recommendations for improving student understanding of statistics through IIR and informal statistical reasoning more generally. Zieffler, Garfield, Delmas, & Reading (2008) summarized these recommendations both in terms of IIR and general informal statistical reasoning through a review of the findings of studies on IIR. They identified several research-based principles related to the learning of
informal reasoning more generally and suggested that these more general principles applied to all types of informal statistical reasoning.

The most striking of these principles is that increased content knowledge is not likely to improve informal reasoning abilities and neither is biological development or life-experience (Perkins, Farady, & Bushey, 1991). Instead of these factors, specific instruction in how to reason informally has been shown as a path for improving this type of reasoning (Schoenfeld, 1982). Based on these findings related to informal reasoning in general, it seems reasonable to expect that developing IIR is not a matter of students needing to learn particular elements of formal statistical content. Based on these studies, it is also not a matter of waiting until children are the right age. It is a matter of addressing IIR directly, which can, and should, be done at a young age.

IIR should be understood in the elementary grades, not just for its own sake, but also for its potential to impact formal statistical understanding. Addressing IIR can impact students well beyond the development of the specific components of IIR. This is because informal statistical reasoning is an important step along the way towards formal statistical reasoning (Zieffler et al., 2008). Formal statistical reasoning encompasses a large portion of what middle and high school students are expected to know about statistics. Such learning has the potential to be supported by focusing first on IIR in elementary school.

In spite of these important benefits, noticeable gaps exist in the research on it, especially at the elementary grade levels. A variety of researchers have called attention to this gap suggesting more research be conducted to understand the statistical reasoning
abilities of students at the earliest stages of schooling (English, 2012; Franklin et al., 2005; Perry and Docket, 2002; Paparistodemou and Meletiou-Mavrotheris 2010). These types of studies are necessary given the research-established benefits of this type of statistical understanding and given the incompleteness of the mathematics and statistics education communities’ knowledge about what IIR looks like and how to engage students in it at the elementary level.

The focus on IIR in the early grades is not only advocated by the mentioned researchers, it is also advocated directly by GAISE. In their description of Level A learning goals which apply to the earliest stages of schooling, GAISE states that students should be able to, “…learn how to use basic statistical tools to analyze data and make informal inferences in answering posed questions” (Franklin et al., 2005, p.23). Additionally, under their description of the learning goals of the Formulate Question portion of the statistical process, GAISE recommends that students understand the difference between what a statistical solution looks like when compared to a mathematical solution. When dealing with mathematical problems you are often able to arrive at one correct solution. However, engaging with IIR provides the opportunity for students to be confronted with the inherent uncertainty within statistical problems, where the best that can be done many times is a set of “solutions” which are most likely to occur.

With these benefits in mind, this study investigated the results of using one approach designed to engage students with informal reasoning about data in the elementary grades. This was particularly timely given the current state of statistics
education in the elementary grades. The Common Core State Standards of Mathematics (CCSSM) unfortunately encourages the study of statistics and data with a very light hand in elementary school (National Governor’s Association Council for Best Practices, 2010). Students in grades K-2, for instance, are expected to be doing little more than sorting items into appropriate categories and counting those items. In fact, data plays a similarly small role in CCSSM until 7th grade when formal statistics education is recommended to begin. Thus following the CCSSM, there is no attention to informal statistical reasoning before students are hit with the majority of their formal statistics education in grade 7. This transition could be smoothed out by focusing more on developing students’ informal statistical reasoning in elementary school.

**Stories, Questioning, and Statistics**

In order to address IIR with elementary students in a way that is both natural for them and practical for the classroom, this study leveraged the typical classroom practice of storytelling along with discussion around those stories. For the purposes of this study, the definition of “story” that was used drew heavily on the work of Zazkis & Liljedahl (2009) who summarized and codified other researchers’ ideas on the subject. To summarize their work, they described a story as a mechanism for establishing meaning by describing a conflict and by using a structure with a beginning, middle, and end. Zazkis & Liljedahl (2009) valued several components of stories, including their complex way of communicating concepts, facts, emotions, and ideas. This complexity highlights a difference between stories and typical story problems and provides one rationale for utilizing stories in this study. In stories, the data that the students are confronted with is
inseparable from a rich, complicated context. This rich, complex context is one way to mimic the real world situations in which one might solve a statistical problem. Initially stories were viewed as a vehicle for communicating data and context while additionally providing a natural opportunity for moments of discussion where students could reason within these contexts informally. Since all stories establish a context around which discourse can occur, an expectation was that any story could be adapted for the purposes of directing this discourse toward the ideas of IIR.

Although stories are ubiquitous in early elementary school classrooms, using stories to teach mathematics is a fairly uncommon classroom practice. Traditional school mathematics treats the domains of mathematics and literacy as distinct, although there have been periodic moves toward integration of the two subjects.

Recent standards documents have remained largely silent on this specific issue. If classroom teachers are going to take advantage of the affordances of using storytelling to teach mathematics, they must rely on the curriculum or themselves. For a specific reference to teaching mathematics through storytelling, one needs to go back to the 1989 Curriculum and Evaluation Standards for School Mathematics put forth by NCTM which promoted, “the use of children's books as a vehicle for communicating mathematical ideas” (NCTM, 1989). The CCSSM does not address this issue.

Particular curriculum programs handle stories and mathematics in a variety of ways. Scott Foresman Addison Wesley (SFAW), an example of a widely used traditional text at the elementary school level, uses stories together with mathematics in what might be characterized as a “typical” way. They are used as introductions to topics and units to
set the scene and prompt the mathematical learning that is about to take place. However, this does not even occur very frequently. In a description of their “Big Books” they state that, “These Big Book versions of the chapter-opener stories help improve your students' math understanding and prepare them for the upcoming chapter. They're the perfect format for shared reading in large and small groups! Suggestions for developing reading skills in mathematics are included.” (PearsonSchool, 2012). The last statement is particularly telling. The focus is on developing reading skills during mathematics lessons, which is entirely different than developing mathematical skills through reading.

In the reform-oriented curriculum program *Investigations in Number, Data, and Space*, stories are utilized in two main ways. The first way is to introduce, situate, and prompt activities, in much the same way as SFAW. The authors state: “In K-2, there are also a handful of units, most of them in Kindergarten, that suggest using a piece of children's literature to introduce an activity” (TERC, 2012). This is done to engage the students in the context, to activate prior knowledge, and to preview upcoming content. The second way the use of stories in mathematics is encouraged in this curriculum is through the Family Letters that provide reading activities for parents to do with their children. Parents are provided with a list of stories with mathematical content and are encouraged to read and discuss these with their child.

*Math Trailblazers* is another NSF-Funded, reform-oriented K-5 curriculum program. The overall purpose statement for this curriculum indicates their focus. *Math Trailblazers* seeks to integrate mathematics, science, and language arts education, and part of this integration of subject areas involves a use of stories. Within their overview
statements of the curriculum, the curriculum authors describe the role of stories as, “Using trade books and original stories to launch or extend mathematical investigations” (Kendall Hunt, 2011, p.2). This includes the use of “Adventure Books” which are original stories that illustrate to students how mathematics and science can be used outside the classroom. In spite of the use of mathematically designed trade books and a focus on the contextual uses of mathematics, *Math Trailblazers* still positions the use of stories in introductions or as extensions. The stories are not, in most cases, at the heart of the mathematical lesson nor used to teach mathematics content.

While ways of integrating mathematics and stories exist in these curricula programs, none of the formats place stories at the heart of a classroom mathematics lesson. Research on the use of stories to teach mathematics confirms these examples as representative. Anderson, Anderson, and Shapiro (2004), report that the majority of research done in this area has involved the utilization of literature as the springboard to initiate discussion of mathematical content and nothing further.

This study placed stories and discussions about those stories at the center of the statistics lesson in order to position students as inference makers within a rich, real-world context. Research on using stories to teach mathematics describes the many benefits of utilizing stories. However, much of this research still focuses on using stories to engage students in topics or ideas as opposed to teach students mathematical or statistical content. One exception is a study by van den Heuvel-Panhuizen, van den Boogaard, & Doig (2009) in which they found that storytelling provided an effective environment for mathematical learning to take place causing both student engagement in the tasks to
increase and student achievement to rise. Another exception is a study by Anderson, Anderson, and Shapiro (2004). They found that stories provided a place for the development of genuine mathematical discourse. Based on these ideas, using stories to initiate mathematical discourse is one principle that motivated the approach designed for this study. It was anticipated that utilizing stories would be especially valuable in creating discourse around IIR given that they provide a rich and complex context for reasoning about data and that a multitude of stories could be adapted for this purpose. Stories were viewed as the vehicle for statistical thinking with the primary impact on students’ IIR coming from the discourse built around the stories.

For this study, the discourse around IIR was designed to happen during specific “moments of discourse and debate” during the story. These moments will be described in more detail in the Chapter 3, but suffice it to say that the goal of the storytelling was to engage students in discourse so that informal student thinking could emerge that involved reasoning, justifying, and critiquing predictions. Cazden (2001) describes effective modes of discourse, mainly occurring in nontraditional classrooms, as serving to scaffold students’ ability to think in a way that provides opportunities to reconceptualize, internalize and construct knowledge. The “moments of discourse and debate” crafted for this study served to scaffold the discussion in this way and break the traditional discourse pattern of teacher initiation, student response, and then teacher evaluation. Cazden contends that this traditional pattern is more suited for the teaching and learning of skills rather than the understanding of concepts and ideas. Therefore, the effective, nontraditional modes of discourse described by Cazden were utilized in this study in
order to effectively engage children in IIR where thinking about statistical problems, like making predictions based on data, cannot be reduced to following a set of procedures.

Additionally the work of Wood (1999) and Wegerif, Mercer, and Dawes (1999) serve to explain the importance of the right kinds of discourse and debate. Wood (1999) focuses on using argumentation and disagreement as a catalyst for discussion and reasoning. Wegerif, Mercer, and Dawes (1999) expand on this by saying that disagreement for disagreement sake is not productive, and that group discussion must be constructive in order to have a positive impact on individual student reasoning.

If mathematical discourse related to stories and directed towards conceptual statistical ideas is to be achieved, questions must be posed by the storyteller to encourage listeners to think and to engage with the story and with each other in ways different than they would otherwise. In a study on high-quality teaching, Leinhardt & Steeles’ (2005) discussed how a teacher’s use of classroom dialog increased student engagement and learning. Having a classroom that valued exploring ideas through questioning was a central component of the teacher’s classroom. These benefits of questioning and discourse will not occur in a classroom where the teacher only reads and the students only listen. The storytelling approach at the center of this study was designed to leverage the benefits of questioning for the purposes of engaging students in IIR.

This process of using storytelling to engage students in IIR involved the researcher orchestrating discussion while reading stories to students and posing prepared and on-the-spot questions to them during planned “moments of discourse and debate”. For this study, this approach was called Storytelling-Questioning. In short, the term
Storytelling-Questioning captures the method that was used by the researcher to engage children in IIR through storytelling. The critical point about this approach is that these two activities (Storytelling and Questioning) happened simultaneously in an integrated fashion. While engaging a small group of students in a story (storytelling), strategic, planned, and spontaneous questions that were built out of the story's context and content, and off of the students' responses (questioning), were posed to students and discussion of the presented ideas was encouraged. The goal of the questioning was to elicit students’ IIR by prompting them to make and evaluate predictions based on data from the story.

It is important to note that a social constructivist perspective on learning underlies the Storytelling-Questioning approach designed for this study. From this perspective, learning is described as “persons in conversation” by Ernest (1994). From a social constructivist mindset, all knowledge is constructed within the individual; however the individual and the social world are inseparably connected. These two realms are so interconnected that it is viewed that the socially constructed world creates and is limited by shared experience (Ernest, 1994). The metaphor of persons in conversation is crucial to understanding the design of this study as it provides a rational for focusing on moments of discourse and debate. Language and socially constructed meanings are central to the storytelling process, and were used in this study to engage individuals in a social conversation that was informal, and yet statistical.

Given that informal reasoning must be specifically taught, that informal statistical reasoning benefits formal statistical reasoning, and that storytelling along with questioning can be used to engage students and elicit mathematical discourse about data,
stories provide a rich context within which students can informally reason. This study was an attempt to operationalize these ideas through a Storytelling-Questioning approach by describing how the common classroom practice of telling stories can be leveraged to encourage IIR. Achieving this has the potential to not only benefit teachers and students, but also mathematics and statistics education researchers.

**Research Questions**

This research was built upon two pillars. The first was informal inferential statistical reasoning. This study specifically relied on the components of IIR (expressing uncertainty, making and evaluating claims, and drawing explicitly from the data) as described by Makar and Rubin (2009). The second pillar upon which this research was built was that statistical thinking can be taught in a valuable way through stories and storytelling. This study specifically relied on the benefits of engaging in discourse and debate within and around an engaging context provided by the stories and accompanying questions. The following research questions were the focus of this study with the intention of connecting these two pillars. Answering these research questions built upon previous work in a new way that was designed to be beneficial for both research and practice. In light of this, the focus of this study was on the following questions:

1. What does Storytelling-Questioning reveal about the similarities and differences in students’ Informal Inferential Reasoning within and across grades K, 2 and 4?
2. In what ways, and to what extent, does the Storytelling-Questioning approach provide students with opportunities to engage in IIR?
Overview of Methods

In light of studying the above research questions, this qualitative methods study was designed to investigate a way of engaging elementary school students in IIR through storytelling called Storytelling-Questioning. Storytelling-Questioning protocols were created for four selected stories and were designed specifically to engage students in discourse and to elicit various aspects of IIR. In order to implement this approach, the researcher acted as a participant-observer, serving two roles during the data collection, storyteller as well as observer. Observations of teachers using these same stories in their classrooms, without the researcher-designed protocols, served to accentuate the affordances offered by the designed questioning. The data was analyzed based on the components of IIR, as well as the types of support provided by students for their inferences. This data allowed the researcher to draw conclusions about the differences in IIR both within and across grades K, 2, and 4 as well as the benefits and limitations of Storytelling-Questioning.

Significance of the Study

This study addresses an important, growing area of statistics education research, IIR. Data from this study will enable the mathematics and statistics education communities to understand more about IIR and its status as well as its development at the elementary school level. Gaps in current research will also be addressed in a novel fashion, through Storytelling-Questioning. Storytelling-Questioning is beneficial for addressing these issues, because it can create an environment where the context of the data is a prominent factor, while also being conducive to eliciting informal inferential
reasoning in elementary students. Exploring this proposed pedagogical method is important because it represents a new and potentially beneficial use for storytelling in the classroom. Additionally, it represents a new and potentially beneficial way to approach the ideas of data and inference in elementary school classrooms, which currently address these issues minimally or not at all. The ability to attend to the IIR in a way that fits within the familiar practice of storytelling is powerfully practical. Thus, this work sought to impact both research (by increasing understanding of IIR in the early grades) and practice (by offering a practical pedagogical method for eliciting IIR).

**Summary and Overview**

As discussed here in Chapter 1, this study is focused on engaging young children in making informal inferences about data through Storytelling-Questioning. This study is focused on the creation, use, and evaluation of this method, which has been designed to provide opportunities for this type of reasoning. The goal of Storytelling-Questioning is to provide young students with these fruitful inference opportunities within the context of a familiar classroom practice of listening to stories. Chapter 2 will detail the research literature on informal inferential reasoning as well as the current research on utilizing stories to teach mathematics. The research findings will also be connected to the current state of affairs related to these issues in school mathematics. Chapter 3 will detail how this important research focus will become actionable in order to answer the posed research questions. This chapter contains a discussion of the methodology of this study as well as plans for data collection and analysis. Chapter 4 will contain a discussion of the results of this study. Finally, Chapter 5 will contain a summary of this study and the
conclusions that can be drawn from the data. This will include implications for future work.
LITERATURE REVIEW

Introduction

This chapter contains literature that formed the basis for this study grouped into three main categories. The first category is informal inferential reasoning. This work establishes what is known and yet to be known concerning the statistical focus of this study. The second category covers the use of stories and storytelling. The review of this literature illustrates how the method designed for this study represents both a new way of engaging students in IIR and using stories to engage students with data. The final section of this chapter represents the connections between the first two foci and centers on key findings related to discourse and questioning that were utilized for the storytelling method designed for this study. Questioning about data within stories that focuses children on IIR is the ultimate goal of this work.

Informal Inferential Reasoning

Statistical Reasoning

Statistical thinking requires a blend of abstract mathematical ideas with concrete information about data and context. Many statistics education researchers who have studied statistical thinking describe it in this way. For instance, Wild & Pfannkuch (1999) state, “The raw materials on which statistical thinking work are statistical knowledge, context knowledge and the information in data” (p.228). This idea is echoed by Cobb and Moore (1997) who also describes how statistical learning cannot happen apart from accounting for the context of the data. It is this interaction between statistical knowledge, context knowledge, and the data which makes statistical thinking different
from other kinds of mathematical thinking and which requires special attention from researchers.

**Research on Informal Inferential Reasoning**

One growing area of research on statistical thinking and learning focuses on Informal Inferential Reasoning (IIR). IIR is a relatively recent construct without a consensus definition. Many different perspectives have been used in IIR studies. For example, Zieffler, Garfield, Reading, and Delmas (2008) viewed Informal Inferential Reasoning as, “the way in which students use their informal statistical knowledge to make arguments to support inferences about unknown populations based on samples” (p.44). Ben-Zvi et al., (2012) defines IIR as informally drawing conclusions from data about populations while attending to issues of sampling. Paparistodemou and Meletiou-Mavrotheris (2010) based their study of informal inference on the following three components: (a) data-based argumentation, (b) data-based argumentation with generalizations, (c) data-based argumentation with chance. These three components illustrate three important qualities of informal inferential arguments: they are based on data, they provide some prediction of generalization, and they address the natural variation that is an important component of thinking statistically.

Makar and Rubin (2009) attempted to capture these different perspectives and provided a definition for IIR. They utilized a definition for IIR that is summarized in Table 2.1. This definition is more general in nature. It more easily accommodates the storytelling component of this study since stories often do not involve explicit mathematical definitions. Overall, Makar and Rubin (2009) view IIR as consisting of
making “probabilistic generalizations about data”. According to them, this can be divided into three components: making and evaluating claims, drawing explicitly from the data to support those claims, and expressing uncertainty. These components are presented in the table below and will serve not only as the working definition of IIR for this study, but also a first-round coding scheme for the data.

Table 2.1

*IIR Components from Makar and Rubin (2009)*

<table>
<thead>
<tr>
<th>Components of Informal Inferential Reasoning</th>
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<tbody>
<tr>
<td>1. Making statements that make or evaluate a claim that goes beyond the sample data</td>
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<tr>
<td>2. Making statements that contain explicit references to the data that the inferences are built upon</td>
</tr>
<tr>
<td>3. Making statements that articulate uncertainty</td>
</tr>
</tbody>
</table>

These statistical concepts might seem complex for young elementary school students. However, given appropriate contexts and questions these components of IIR are approachable for young children. Examples from both Makar and Rubin (2009) and this author’s unpublished pilot study will help to clarify what is meant by these three components, especially in the context of young students’ reasoning. In the pilot study for this dissertation, students were read a story about elementary school students participating in a school contest to read a certain number of books. The main character could not seem to find a book he wanted to read. When students were asked a question about what other types of books the character might like based on what was known about
him, one student said, “He might like a book about a video game like a game that has a book to it.” This is an example of a claim that goes beyond the sample data, which are claims made about a larger population based on a smaller set of data. This is because the smaller sample that the student is referring to is the sample of kinds of stories that the main character does not like as well as the data from the story that indicates the main character’s interests. The student is making a claim about the larger population of all books by stating which of them might appeal to the main character, based on two samples of data about books he dislikes and interests that he has.

Another component of IIR is being explicit about the data used to make claims. Consider the following claim: “I think there will be 25 books that he likes on the shelf, because he liked 3 out of the 6 books he read.” This would be an instance of specifically referring to the data upon which the claim is based. The data on which claims were based was considered quite broadly to include any information that seemed to ground why the students reasoned in a particular fashion. This could include explicit data from the text or visuals of the story, but could also involve a more subtle reliance on data. For example, their reasoning could be built upon implicit information from the text or visuals or information from their own personal experiences related to the context of the story or question.

The final aspect of IIR is attending to uncertainty. Makar and Rubin (2009) provide an example of this in the context of students using a set of data to estimate the average height of an eight-year-old. They say, “…students may suggest the typical height is around 130-138 cm, rather than reporting more precisely that the typical height is 132
This is seen as addressing uncertainty since reporting that the typical height might be around 130-138 cm allows for the possibility that the students’ sample data does not describe the true population in a representative way. An important point to make here is that young students will likely think only of the mode when thinking about typical values. However, even this kind of reasoning has a hint of attending to uncertainty within it. Contrast saying that, “The typical population height would be 130 cm” with saying that, “The population height IS (or will be) 130 cm” Implicit in acknowledging that there is a typical value is the fact there are not-so-typical values. The latter does not attend to the uncertainty inherent in generalizing from a sample because it does not acknowledge the possibility of other solutions. As such, the word typical does include an inherent meaning of a range of possibilities, although students may not have this understanding and may not utilize the term in this way. So, when discussing uncertainty with students it is important to ask for clarification about words like typical since there could be a greater sense of uncertainty hiding behind that term. Students can also informally articulate uncertainty in more straight-forward ways by using words and phrases like: probably, maybe, I’m not sure, or it could be this or that.

To further clarify IIR it is helpful to contrast the ideas of informal statistical reasoning with formal statistical reasoning. Zieffler et al. (2008) contrasts these ideas by saying that the latter is concerned with formal procedures like testing hypotheses based on data distributions and creating confidence intervals, whereas IIR has its basis in intuitive, non-procedural knowledge. Voss, Perkins, & Segal (1991) further clarify this point by stating that, “Informal reasoning (sometimes referred to as informal logic) has
been defined by cognitive psychologists as the type of reasoning that occurs in non-deductive situations, such as decision making, that is employed in everyday life” (as cited in Zieffler et al. 2008). It is important to note how storytelling and stories fit within this definition of informal reasoning as they are traditionally non-deductive situations that engage students in issues of everyday life.

Research related to IIR has been beneficial both in elaborating it as a conceptual component of statistical thinking and by providing concrete recommendations for improving student understanding of statistics. For instance, Paparistodemou and Meletiou-Mavrotheris (2010) studied third graders’ abilities to make data-based arguments when they approached statistics by working on a project and utilizing Tinkerplots® software. The data that the students engaged with was real as it was collected in their own classroom. They contend that: “At this age, personal experience and interest play a key role in children’s interactions with data. Personal interest is important for children’s involvement in reasoning about informal inference” (Paparistodemou and Meletiou-Mavrotheris, 2010, p.4). Their study illustrates that young children are capable of engaging in IIR if an engaging personal context is provided.

In another study of young students engaging in IIR, Ben-Zvi, Aridor, Makar, and Bakker (2012) studied fifth grade students’ articulations of uncertainty while doing data-based investigations while using Tinkerplots software. The tasks in their study were designed around the following principles: generalizations based on data, evidence based reasoning, probabilistic language, and growing samples. The Storytelling-Questioning protocol’s questions used in this study fit with these four task-design principles. Ben-Zvi
et. al. (2012) found that students began the investigations expressing either absolute
certainty or absolute uncertainty while making inferences, but that through the process of
engaging in their tasks based on the four components listed above, they began attending
to uncertainty in a more statistically appropriate way. For example, the students moved
from statements of extreme certainly to statements like, “It seems like …” or “The
chances are small that …” (Ben-Zvi et al., 2012). They also found that even though the
students did not have formal instruction in the ideas of sample and population, they were
able to engage in sample growing tasks.

**Current Approaches to Informal Statistical Reasoning**

Due to the limited nature of research on the implementation of the ideas of IIR
within classrooms, it is necessary to discuss informal statistical reasoning more generally.
The importance of reasoning about data is apparent in the GAISE document (Franklin et
al., 2005). It advocates structuring statistics education around a process of statistical
investigation containing the following steps: (1) Formulate Questions (2) Collect Data (3)
Analyze Data (4) Interpret Results. It is recommended that these steps be used at all K-
12 grade levels and they represent a particular mindset. Statistics is a process, and a
process that students must engage in, in an authentic way.

Research has shown that pre-service teachers struggle with these ideas perhaps as
a result of not having sufficient exposure in K-12 (Leavy, 2009). Leavy studied pre-
service teachers’ ability implementing statistical investigation lessons centered on IIR.
She documented the difficulties that these pre-service teachers had in executing these
investigations and found that establishing a sufficiently rich context for children to reason
within was problematic for them. It is reasonable to extend these issues to all teachers. Without materials designed to do so (and even with them), establishing rich contexts for investigations about data is not trivial. Therefore, techniques or materials that could help establish contexts rich enough to do investigative data explorations are needed. Additionally Leavy found that pre-service teachers were also unable to ask appropriate questions that would encourage or elicit IIR. If teachers were provided with a method to more easily establish a rich context within which to operate, the recommendations of GAISE and the research recommendations about focusing on Informal Inferential Reasoning would be more feasible to implement.

While the recommendations from the GAISE document are clear, unfortunately it is much less influential than other standards-type documents in the United States. The Common Core State Standards for Mathematics (CCSSM) (2010) clearly has more national influence, now adopted by 46 of the 50 states. In contrast with previous standards documents like NCTM's *Principles and Standards for School Mathematics* (2000), the CCSSM minimizes the study of statistics and data in elementary school. Students in grades K-2 are expected to do little more than sort items into appropriate categories and count those items. A majority of the standards under the Data and Measurement strand in grades K-2 attend only to measurement. Statistical reasoning is only present at the early elementary grade levels to the extent that certain Standards for Mathematical Practice are enacted. Practices such as, Reasoning Quantitatively and Abstractly, and Critiquing the Arguments of Others provide a space wherein statistical reasoning might happen, but this space is neither large nor explicit.
The lack of attention at the elementary grades is accentuated in the middle grades. A change takes place in middle school when data and formal statistical ideas become a focus. This harsh transition needs to be smoothed out by focusing more on developing students’ informal statistical reasoning in elementary school. However, given the fact that the CCSSM does not encourage it, it is more imperative that classroom activities be made available that teachers could easily implement.

Approaches to data in K-2 within the classroom can vary from the light treatment encouraged by the Common Core to the substantial treatment advocated by the reform-oriented elementary level curricula, *Investigations in Number, Data, and Space*. In this curriculum, grades K-2 students do more than just classify and count data; they organize data, describe data and even engage in designing and carrying out “Data Investigations” (TERC, 2012). These Data Investigations require students to go through an investigative process that includes interpreting the data and is consistent with the 4 phases recommended by GAISE. However, not every teacher has access to materials such as these that promote statistical reasoning and it may be challenging to capitalize on opportunities to encourage the specific components of IIR.

**Stories and Storytelling**

In addition to engaging students in the 4-phase data analysis process, some researchers have suggested the use of stories and storytelling to encourage mathematical reasoning. What else captures a child's imagination and attention like a story? A story's educational value is obvious when the goal is increasing vocabulary, improving listening, or improving reading. The benefits of storytelling in the classroom also extend well
beyond this; they are numerous and well-documented by researchers. Haven (2000) described 10 benefits of using storytelling in the classroom. Among these benefits are that through storytelling, both concepts and facts are remembered longer and better, student engagement increases, problem-solving skills are improved, and learning is motivated. Zazkis & Liljedahl (2009) add to this saying, “The value of the story to teaching is precisely its power to engage the student’s emotions and also, connectedly, their imaginations in the material of the classroom”. According to these authors the results of this include sparked interest, improved memory, reduced anxiety, and increased rapport among participants. Egan (2004) stated that stories have two aspects that make them powerful, first they communicate information in a memorable way, and second they can shape the hearer's feelings about the information. These are benefits regardless of the school subject. How can these affordances be leveraged for the teaching and learning of mathematics and statistics? There is reason to expect positive impacts on statistical reasoning given that “…young learners begin to reason about informal inference when their interest in a task is high” (Paparistodemou and Meletiou-Mavrotheris, 2010, p.4).

Using Stories and Storytelling to Teach Mathematics

Research on teaching mathematics through storytelling is limited. “Empirical research on how narrative can be used as a cognitive tool to support mathematical thinking seems to be in its infancy” (Roberts & Stylianides, 2012, p.2). It is important at this point to note here the difference between narrative or storytelling and story problems. Much research has been done on story problems in mathematics education and in education in general. Research on story problems is quite different than research on
teaching mathematics through storytelling. Story problems often are comprised of mathematical procedures with some loose context that is often artificially attached. Stories give life to a context and can make a person think, feel, imagine, and remember in a way that is rich and reflective of lived experience. Teaching mathematics through this medium requires the view that the contextual material gives rise to the mathematics as opposed to being attached to the mathematics like an accessory.

In a study that looked at teaching students mathematics through storytelling, van den Heuvel-Panhuizen, van den Boogaard, & Doig (2009) found that storytelling provided an effective environment for mathematical learning to take place causing both student engagement in the tasks to increase and student achievement to rise. Actual mathematical learning was taking place during the story time because of the content of the story and because of the questions asked. These researchers used a story about a sheep weighing and measuring his wool and asked students questions like, “And how can you tell that he has gotten fatter?” Students informally extrapolated and looked for patterns based on what they had already seen.

What is also important about the work of van den Heuvel-Panhuizen et al. (2009) is that they used stories that were not written specifically as mathematical stories. Rather, they used basic books, and in some cases even picture books without words. Their questioning strategies while using the picture books are what elicited the mathematical conversations. The work of Anderson, Anderson, and Shapiro (2004) adds to this by showing that stories provide a place for the development of genuine mathematical discourse. They studied the conversations that occurred between parents and children as
they read stories that contained a mathematical emphasis. Productive mathematical
discourse occurred on topics like number through the course of the reading.

**Discourse and Questioning**

**Discourse as Learning**

Utilizing stories and focusing on IIR is not sufficient to describe the Storytelling-
Questioning approach completely. The S-Q Approach has one additional feature, which
is situating students’ engagement with stories within an environment of discourse. This
next section will describe a selection of studies that have mainly identified the qualities of
effective discourse along with discussing the impact that high-quality discourse can have
on learning. These findings support the discourse environment developed as part of the
Storytelling-Questioning approach utilized in this study.

**Qualities of Effective Discourse**

Wood (1999) focused on the role of an elementary school teacher in establishing
an environment where argumentation, discussion, disagreement, and diverse ideas could
occur. One central finding was the fact that “challenges” seemed to be a central
component of these classroom environments. Wood (1999) defined these challenges as a
“… statement or question of disagreement about the explanation given” (p.179) and
described how these challenges were created by the teacher.

First, the teacher established an expectation for disagreement through her opening
conversations with her students. This was done through requesting and valuing multiple
opinions or perspectives on a particular issue and then asking students to react to each
other’s thoughts. Then the teacher assisted students in learning how to participate in the
disagreement by modelling the kinds of questions and responses she was hoping to encourage. Of note in this phase was the teacher’s use of questioning. The teacher directly asked students to engage with the disagreement by asking, “Do you agree with her?” or “Do you have another idea?” Finally, the teacher helped students engage in forming arguments, again primarily through questioning, by asking “How do you know that?” and “What do you think about that?” The students were obliged to justify their thoughts and thus engage in argumentation based on a challenge that was created.

Wegerif, Mercer, and Dawes (1999) placed even more emphasis on the issue of utilizing argument and disagreement in the classroom. They provided additional details on the kinds of argumentation and disagreement that were most productive for student reasoning, labeling this type of talk “Exploratory Talk.” They explained that “Exploratory talk occurs when partners engage critically but constructively with each other’s ideas…” (Wegerif, Mercer, & Dawes, 1999, p.496). The important point here is that the ideas are in the forefront and are engaged with in a constructive fashion. This stands in contrast to the other two types of talk these researchers identified, Disputational Talk and Cumulative Talk. Cumulative talk was described as being only constructive, where ideas are put forward without any real discussion to evaluate them. Disputational talk was described as being mostly critical and individualistic with everyone sharing their own ideas as counter-examples without engaging with the ideas of others.

Impact of High-Quality Discourse on Learning

Wood (1999) found that the types of classroom discussions described above were productive places for the development of conceptual knowledge. She found that students
were able to begin understanding mathematics as a discipline that required reasoning and justification of ideas. As such, students readily engaged in providing reasoning and justification. She attributed this benefit largely to the ways in which teachers establish an expectation and a routine for student engagement. Wood states that, “When these classroom routines became the tacit patterns of interactions, the children no longer found it necessary to direct their cognitive attention to making sense of their social setting and could direct their mental activity to making sense of their mathematical experiences” (p.189). So, it was not only the ways in which these students were engaging with ideas, but the fact that thinking around disagreements was a norm for their mathematics classroom.

The Wegerif, Mercer, and Dawes (1999) study also demonstrated some potential benefits of classrooms focused on Exploratory Talk. They focused on the impact of social reasoning on individual reasoning and found that individuals were able to effectively transfer reasoning done in social situations to improved individual reasoning. In other words, group discussions of mathematical ideas impacted individuals’ abilities to reason in a positive way. One way the authors described this was to identify changes in the ways that various groups of students discussed ideas pre-intervention and post-intervention. They saw groups that were largely disputational before the intervention, meaning they provided their own ideas without justification. By the end of the study the same groups of students provided more elaborate explanations for their ideas and even asked others to expand on their ideas when necessary. In general they found, “Explicit reasons for claims [were] given, challenges [were] offered with reasons, several alternatives [were]
considered before a decision [was] reached, and the children [could] be seen to reach agreement together.” (Wegerif, Mercer, & Dawes, 1999, p.506). These effects were a product of teaching the ground rules for Exploratory Talk and of providing students with the language to engage with mathematics in this way.

Both Wegerif et al (1999) and Wood (1999) seemed to essentially value the same type of discussion. Classroom discussions where differing student ideas formed the center of talk and the class as a whole critiqued and built upon these responses were discussed as productive models for student learning. These authors provided evidence of the potential benefits of having high-quality discussions around disagreements on students’ reasoning. Wood found that students developed conceptual knowledge as a result of the rich discussions that took place in the classroom in her study. Wegerif et al. (1999) found that individuals were able to effectively transfer reasoning done in the social situation of the classroom to improved individual reasoning. There was an expectation that the degree to which the questioning stance of the Storytelling-Questioning protocol at the center of this study aligned with creating this type of discourse would be the degree to which the student participants would demonstrate the same benefits.

**Summary**

To synthesize these findings on IIR, stories, and discourse, discourse around disagreements is a unifying concept for this study. First, it has been shown to be an effective method of engaging students in conceptual reasoning. In addition, these disagreements can be generated by the use of complex and engaging contexts and stories facilitate this. Disagreements are also a productive way of thinking about IIR, since
making predictions, defending those predictions and evaluating the likelihood of predictions are natural components of any debate. This understanding of generating discourse and debate as a way to unite stories and IIR formed the foundation of the methods described in Chapter 3.
METHODOLOGY

This qualitative methods study was designed to investigate engaging elementary school students in IIR through storytelling. This goal is consistent with the types of studies best suited for qualitative methodologies, as described by several authors. Marshall and Rossman (2011) describe qualitative research as fundamentally interpretive and emergent with a focus on context and interacting with the natural world. Eisenhart (1988) describes the qualitative ethnographic research tradition by saying that, “…interpretive methods must be used to make statements about how people understand their worlds” (p.101). This study was situated within the standard classroom practice of storytelling and placed the students’ contextual knowledge of their world and their interactions with the storyteller/researcher at the forefront. Part of the goals of this study was to describe the impact of this contextual knowledge on their reasoning about data that is in context. Additionally with the relative newness of studies seeking to understand IIR, this work was naturally exploratory and to some degree, emergent. As such, a qualitative approach best positioned the researcher to answer the stated research questions.

Participant-Observer

Within qualitative methodologies, this study utilized the ethnographic tradition of a participant-observer. Participant-observers are exactly what the name suggests. “A participant-observer observes and participates in activities without being identified as belonging to one of the social categories of the community being observed” (Moschkovich & Brenner, 2000, p.476). The researcher was a participant in the data
collection in that he took on the teachers’ role of storyteller by reading a story and asking the students questions based upon it. The advantage of the researcher, as opposed to the classroom teacher, acting as the Storyteller-Questioner was that the researcher understood the various aspects of informal inferential statistical reasoning and its components. This meant that in the storytelling environments he was better positioned to elicit student responses and rationales as well as adapt to those responses as necessary. It would have taken time to educate classroom teachers on IIR as well as to help them understand the Storytelling-Questioning protocol for eliciting it and a method for doing this was undeveloped and unproven. Without a more complete understanding of IIR at the elementary school level, which is a goal of this study, a model for teacher implementation aligned with the intent of this study could not exist.

The observation portion of participant-observation consisted of the researcher observing the actions of the students both during the process and documenting those observations with field notes written immediately following each Storytelling-Questioning episode and after the fact with audio and video recording. The field notes captured the researcher’s understanding of the episodes in regards to student participation and served to document the decisions that the storyteller/researcher made during the process to elicit student responses. Eisenhart (1988) describes the duty of the participant-observer as faithfully trying to become a member of the group while also trying to look at the scene from an outsider's point of view. Since this presents the researcher with a difficult balance between participating and observing, both audio and video recorders were set up to capture each interaction. This was, in part, so that the researcher could
observe the students from yet another perspective as well as observe his own actions as is recommended by Eisenhart (1988).

Finally, given that the researcher is such a central component in the study from a participant-observer perspective, it is important to understand the researcher’s lens for examining this qualitative data. In some sense, the research is a “tool” used to understand the data. Describing these perspectives and biases help speak to the validity and reliability of the interpretations. These researcher views and biases are described in various places within this chapter. Overall it is important to briefly mention here the researcher’s perspectives on learning. To summarize, this researchers’ perspective on learning is that learning should be student-centered in that learning takes place when students are able to build off of their past experiences and construct new knowledge through discovery and discussion with others around material important to them. This perspective should be kept in mind as the methodological details yet to be discussed are explained.

The qualitative tradition and a participant-observer model aligned with the goals of this study since Storytelling-Questioning and this researcher’s understanding of learning in part because it requires active participation within the community on the part of the researcher. Additionally, asking students questions while reading a story enabled the students to make inferences in a natural, authentic, and informal way that allows them to rely on context and their own understanding of the world in a way that interests them. Thus, Storytelling-Questioning created a natural ground for students to infer and do so informally.
Context of Study

Setting

This study took place in two different, but comparable, suburban K-5 elementary schools in the same school district. School A had approximately 550 students with class sizes ranging from 20-30 students. The demographics of School A included approximately 85% White, 7% Asian, 5% Black, and 4% Hispanic students. Approximately 17% of students at School A were eligible for free or reduced lunch.

School B had approximately 400 students with class sizes ranging from 20-30 students. The demographics of School B included approximately 88% White, 6% Black, 5% Asian, 2% Hispanic students. Approximately 25% of students at School B were eligible for free or reduced lunch. Both schools’ academic performance could be described as above the mean for the state.

Student Participants

This study involved students from Kindergarten, second, and fourth grades. The Kindergarten and second grade students were selected from School A and the fourth grade students were selected from School B. While the original intent was to conduct the study in one school, none of the fourth grade teachers from School A expressed interest in having their students participate in the study. Therefore, it was necessary to solicit participation from fourth grade teachers and students from School B.

Six students from one classroom within each of these grades participated. These students were randomly selected from those students who had parental consent. The proportion of students with parental consent within each classroom was between one-half
and two-thirds. Random selection of students was used in an attempt to minimize the variation present across the three grades that might be attributed to the particular students selected. Additionally, once the fourth grade students were randomly selected from those with parental consent, they also provided assent to participate in the study. Prior to data collection, the researcher visited each classroom at least one time to give students an opportunity to meet the researcher. This, along with discussions with classroom teachers, helped the researcher ensure that student participants would feel comfortable during storytelling episodes. For added comfort in the research setting, the students were allowed to touch, hold, look at, turn on, and ask questions about the audio and video recording equipment.

The six students from each grade were then formed into two different groups of three students who participated in the storytelling episodes separately. This was done to follow recommendations by Morrow and Smith (1990) who studied the effects of group size on young children's ability to comprehend verbal interactions. They found that the Kindergarten and first-grade students in their study comprehended more when they were placed into small groups (of size 3) than students read to one-on-one. They also found that these students comprehended more than when stories were read to the entire class.

Teacher Participants

In order to understand the differences and potential impact of Storytelling/Questioning, three teachers, one from each grade (K, 2, 4) participated in this study. The participating teachers were selected either because they were the only other teacher at the necessary grade level who volunteered to participate or had compatible
schedules for observation if multiple teachers volunteered within a particular grade level. The other part of the selection criteria was that the teacher participants met two particular conditions. First, they had to utilize storytelling within their normal classroom practice, and second, they could not be the teachers of the students selected to participate. The latter condition was important so that the stories used by the teacher participants during observation would be the same as those used by the researcher for purposes of comparison. However, it was necessary that the fourth-grade teacher participant was also the classroom teacher of the student participants due to the fact that there was only one fourth-grade teacher who volunteered to participate in the study. To accommodate this exception, the teacher observation was completed prior to the students’ interactions and the story selected was one that was a part of this study (i.e. used with Kindergarten and second grade groups) but was not one that the researcher utilized with the fourth grade students. In both the teacher observation component and the Storytelling-Questioning component, the stories were new to the students in that the teachers had not used them within their classroom prior to the data collection.

Data Collection

Overview of Research Procedure

Before explaining the details of the data collection, it is good to once again acknowledge the two research questions at the center of this study to provide context for the details to come. First, what does Storytelling-Questioning reveal about the similarities and differences in students’ Informal Inferential Reasoning within and across grades K, 2
and 4? Second, in what ways, and to what extent, does the Storytelling-Questioning approach provide students with opportunities to engage in IIR?

The first part of this study contributed to answering the second research questions and was designed to describe the kinds of questions that the participant teachers asked while utilizing stories in their classroom. This was so that comparisons could be made with the designed Storytelling-Questioning intervention. This was done through classroom observations of one instance of the teachers utilizing storytelling in a way that represented their typical use of stories and focused on the types of questions the teachers posed. Prior to the observation, the teachers were asked to select one of the stories that were going to be used by the researcher. They were asked to incorporate it into their classroom in a way that reflected their typical use of stories and storytelling. The teachers were not informed of all of the details of this study, but were told that the focus of this part of the study was on how teachers typically use stories in their classrooms.

The researcher observed each of the three teachers reading the selected story within their classrooms in order to identify the types of questions the teachers posed during storytelling. Since the stories were the same as those used by the researcher and since the teacher was not exposed to the same questioning used in the study (These questions contained in the Storytelling-Questioning protocols are described in the paragraph directly below.), information gathered from the observations served as a comparison to information gathered from the storytelling-questioning episodes conducted by the researcher. The choice was made to observe teachers using the stories in a whole
class setting rather than in small groups, because whole class storytelling represents the
typical way stories are used by teachers.

The second part to the data collection consisted of the researcher enacting the
Storytelling-Questioning protocol (Appendices A-D) with the six groups of students. The
storyteller/researcher read two books to each group of students and followed the
associated Storytelling-Questioning protocol. In total, four stories were utilized
throughout the data collection. Table 3.1 illustrates the distribution of the stories across
the student groups.

Table 3.1

<table>
<thead>
<tr>
<th>Stories Used by Group</th>
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<tbody>
<tr>
<td>Story</td>
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<tr>
<td>June 29, 1999</td>
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<tr>
<td>Miss Malarkey Leaves No Reader Behind</td>
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<tr>
<td>Sylvester &amp; the Magic Pebble</td>
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<tr>
<td>Nothing Ever Happens on 90th Street</td>
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Note that one story was read exclusively to the fourth grade groups, *Nothing Ever Happens on 90th Street*. The other stories, *Miss Malarkey Leaves No Reader Behind*, *Sylvester and the Magic Pebble*, and *June 29, 1999* were read to groups across grades.

This overlap in stories across grades was intentional and assisted the researcher in
understanding if there is a difference in how students address IIR at different grade
levels. The difference in number of groups exposed to each story is a product of needing
students to be unfamiliar with the story as well as interested and engaged in the interaction.

These storytelling episodes occurred with six groups of three students. Each storytelling episode lasted between 15-30 minutes. For the kindergarten and second grade groups, there were two meetings on back-to-back days with the first half of the story covered on day one and the second half of the story covered on day two with each session lasting 15-20 min. For the fourth grade groups, it was possible to complete the story in one episode of 20-30 minutes. At school A, these episodes were physically situated within the school library in a quiet corner where it was common for reading activities to occur. At school B, these episodes were physically located in a separate room set aside for work with small groups.

While reading a story to the students, the researcher asked prepared and impromptu questions that required students to make use of their Informal Inferential Reasoning about data based on the Storytelling-Questioning protocols. As per the protocols, the researcher asked clarification questions any time the students' reasoning was not completely clear. A more detailed rationale for the construction of these protocols can be found later in this chapter. Following each storytelling episode, field notes were taken detailing the thoughts, observations, and rationales of the researcher and shortly following each episode the data sources were double-checked to ensure they properly captured what was intended.
Types of Data

To help summarize the research methods, the following types of data were collected. The classroom observations were transcribed live by the researcher, recording only the questions that the teacher asked during storytelling. In order to capture the students’ reasoning adequately, each storytelling-questioning episode was video recorded and audiotaped. The audiotaped conversations were transcribed and enhanced by the video for analysis. Since research suggests that gestures are an important part of students' reasoning (Roth, 2001), the video data was used to capture non-verbal gestures that students made such as nodding heads in agreement, shaking heads in disagreement, shrugging shoulders, pointing to various components of the book, or pointing to various locations within the physical library setting. The video data also served as a check on the audio transcript (especially in terms of who was doing the speaking) and provided the researcher with an opportunity to make additions to the field notes. This ensured that the transcripts were accurate in terms of what was said and who said it and helped confirm the observations of the researcher. The final data type was the researcher field notes that consisted of thoughts about the types of questions asked, the kinds of questions that were not asked, the instances of student thinking which were pursued further, the instances of student thinking that were not pursued further, the immediate impressions following the storytelling episode, and the reasons for making each of these decisions. Table 3.2 provides a summary of the phases of data collection.
Table 3.2

*Phases of Data Collection*

<table>
<thead>
<tr>
<th>Data Collection Phase</th>
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<tr>
<td>Teacher Storytelling Observations</td>
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<td>S-Q Episodes with Grade 4</td>
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<td>S-Q Episodes with Grade 2</td>
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<tr>
<td>S-Q Episodes with Grade K</td>
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**Storytelling-Questioning Protocols**

**Story Selection**

The Storytelling-Questioning protocols were designed to elicit opportunities for students to reason informally about data within and connected to a story. These protocols served both as a general guideline for the types of questions to ask during the storytelling and, at times, as a script particular to an individual story. The first step in developing these protocols involved selecting appropriate stories. Story selection was done based on the framework presented below in Table 3.3, which was developed based on results from a pilot study (Smith, 2013). This framework was designed to capture factors important to Storytelling-Questioning. This framework is not intended to be incredibly strict with regard to the stories selected for this study. It was designed to ensure that this study
would have the best opportunity to engage students. It is important that after the Storytelling-Question protocols are studied and refined that teachers can implement them with most any story they select. It was the view of the researcher that most stories will be adaptable for the purposes of engaging students in IIR. Given this, the story selection mattered only in the sense of providing the best possible opportunity for the engaging students in this way.

The important factors of the stories included the opportunity for students to engage with numerical and categorical data presented both in the text and in the visuals. Another central premise of this work is that a desirable story must have an engaging context rich enough for students to reason in a complex way. Finally since it is important to understand students’ reasoning and how it progresses, repetition within the story is important since this allows opportunities for students to revise previous inferences based on more thought or new data.

Each story under consideration was rated on a scale of 0-2 (Weak – Neutral – Strong) to describe the affordances of the story within each category listed below. This provided a total score that was used to determine stories that would provide the most affordances for eliciting IIR. The candidate stories for selections came from examining the common items on lists of teacher-generated “best stories for second grade” (or Kindergarten or fourth grade) found on the internet.
Table 3.3

*Framework for Selecting Stories*

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Weak – Neutral – Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data - Textual</td>
<td>Data (numerical and categorical) is visible within the text of the story.</td>
<td>0 – 1 – 2</td>
</tr>
<tr>
<td>Data - Visual</td>
<td>Data (numerical and categorical) is apparent in the visuals of the story.</td>
<td>0 – 1 – 2</td>
</tr>
<tr>
<td>Context</td>
<td>Context of the story is likely to be familiar to most students</td>
<td>0 – 1 – 2</td>
</tr>
<tr>
<td>Repetition</td>
<td>Provides opportunities for students to revisit their previous claims in light of new data</td>
<td>0 – 1 – 2</td>
</tr>
<tr>
<td>Engaging</td>
<td>The text and the visuals are interesting, entertaining, and engaging</td>
<td>0 – 1 – 2</td>
</tr>
<tr>
<td>Complexity</td>
<td>The story is complex enough to create questions about it that are not trivial or obviously predictable</td>
<td>0 – 1 - 2</td>
</tr>
</tbody>
</table>

The four stories that were chosen are discussed below. Each story received, at the least, a strong rating (2) in every category except for one.

**June 29, 1999**

The story chosen for the Kindergarten groups only was, *June 29, 1999* written and illustrated by David Wiesner (1992). *June 29, 1999* is about a girl named Holly Evans who, for a class science experiment, sends packages of planted vegetable seeds into the air via balloons. Holly wanted to test how the vegetables grow in the upper atmosphere. Then on June 29th strange things begin to happen: extremely large vegetables begin floating down from the sky and landing across the country. The story is about this event and whether Holly’s experiment caused these huge vegetables to fall from the sky.
This story scored strong according the framework in Table 3.3 in several areas. 

*June 29, 1999* provides opportunities to consider Data – Textual information. The text includes scientific experiments, dates, different types of vegetables, and different locations in the U.S. Each of these instances offers opportunities for the storyteller to point out some data and ask for inferences. Data is also present in the visuals. Pictures of different kinds and different amounts of vegetables and pictures of the different locations allow the storyteller an opportunity to create data based on these visuals. This story also scored strong in terms of repetition. There is an overall story arc that has readers wonder if Holly is responsible for the events of the day. Also, there is a pattern of different types of vegetables floating down onto different cities. These aspects of the story allow for the storyteller to ask the same or similar questions, which provides students with the opportunity to revisit their previous claims based on new information. This story also scored strong in terms of engagement and complexity. The story and visuals are interesting and beautiful and come from an award winning author. The story is also complex enough to create non-trivial or predictable questions. *June 29, 1999* only received one neutral rating according to the framework in Table 3.3. This was in the area of context. This story lends itself to questions about scientific experiments and different types of vegetables. Some students might not be familiar with the scientific process or with many different types of vegetables.

**Miss Malarkey Leaves No Reader Behind**

The story chosen for kindergarteners and second graders is *Miss Malarkey Leaves No Reader Behind* by Judy Finchler and Kevin O’Malley with illustrations by Kevin
O’Malley (2006). It is important to note the reasoning behind the choice of this story. *Miss Malarkey Leaves No Reader Behind* is a story about a teacher’s quest to find a story that the main character likes to read. The main character has many interests, but reading is not one. This story describes the process of finding the main character a book that he likes while their school is also attempting to read 1,000 books during the school year. This story scored strong based on the framework from Table 3.3 for several reasons. First, the story has an interesting and engaging plot. Second, there are several instances within the story utilizing numerical or categorical data. These instances provide natural places for constructing questions that would elicit IIR. For instance, at one point in the story there is a bulletin board with ribbons on it. The ribbons represent the number of books each child had read. Based on this students were asked to infer how many ribbons they believed that another student (not currently pictured on the board), Ellen, might have on the board based on data from the story. Another important aspect of this story is that it has some built in repetitive elements that make natural places for asking students to revisit previous claims. This was done routinely, for example, by asking how many stories the students thought that the main character would read during the next month. As the story progressed, students were asked this question again and again to give them an opportunity to make new claims (or the same claims) based on the data from the newest parts of the story. Finally, this story was selected because its context (reading and school) is a context familiar to all student participants.
Sylvester and the Magic Pebble

The story chosen for both the second and fourth grade groups was *Sylvester and the Magic Pebble* written and illustrated by William Steig (1969). This story is about a donkey named Sylvester who finds a magic pebble and wishes that he would be turned into a rock so that he could escape a lion. Unfortunately Sylvester could not wish himself back to a donkey, because he had become a rock and could not hold the magic pebble. His parents and friends look for him but do not find him. Sylvester is eventually reunited with his family when they picnic near the rock and find the pebble.

This story scored strong in most of the categories provided by the framework in Table 3.3. Both the text and the visuals provide opportunities for the storyteller to create questions around data. For example, one of Sylvester’s hobbies is collecting pebbles. At one point there are eight pebbles on the table as well as a jar partially filled with a countable number of pebbles. A question could be asked based on the colors of pebbles that Sylvester has already found, “If he found another three more pebbles, what colors could he expect to get?” The story also addresses the weather and the odds of the weather changing as a way of collecting data on whether the pebble was magic. *Sylvester and the Magic Pebble* provided several opportunities for the storyteller to engage students in IIR. The context of the story is a fairytale about a magic pebble. This is accessible for students of this age and thus merited a strong rating. There are some elements of repetition in this story. There is repetition during the search for Sylvester and in the overall premise of whether he will be found or not. The story also scored strong on engagement. It is an interesting, award winning fable that makes the reader interested in the fate of Sylvester
and whether he will be reunited with his family. The story only scored neutral in terms of complexity. Since the story is a fable, its repetitive elements are somewhat predictable. Additionally since this story involves magic it can run counter-intuitive to the premise of making inferences based on data in the real world. However, there is enough space to create questions of merit.

Nothing Ever Happens on 90th Street

The story chosen exclusively for the fourth grade groups was Nothing Ever Happens on 90th Street written by Roni Schotter and illustrated by Kyrsten Brooker (1997). This story is about a girl named Eve who must write a story as an assignment for class. Eve is uninspired to write and overcomes this by talking with and observing the many crazy characters on 90th street. The people of 90th street give Eve advice on writing her story and her observations lead to an interesting ending.

Nothing Ever Happens on 90th Street scored strong in many of the components of the framework in Table 3.3. In terms of the Data-Textual category, the overall storyline lends itself to students making inferences, because there is some uncertainty in how Eve will write her story. There is also some uncertainty regarding the different characters on 90th street and how their actions fit into the larger story. The visuals of the story are ornate and detailed and provide a rich context out of which the storyteller could elicit IIR. Some of the visual details include lists of items and prices for stores and countable items like pepperoni pizzas. These areas provide a space for creating questions based on this data. In terms of context of the story, it also rates strong. The context of the story is a girl working on a writing assignment for school and describing the people that she meets on a
city street. These contexts are not foreign to students of this age. *Nothing Ever Happens on 90th Street* also excels in terms of being engaging and complex. There are many details provided by both the text and the visuals which are interesting and at times unpredictable. The only area in which this story received a neutral rating was in repetition. The single repetitive element of the story is the constant element of how the characters Eve encounters will fit into her stories. This is an idea that could be revisited at various points in the story so that students have a chance to revisit their thinking based on new evidence.

**Developing Storytelling-Questioning Protocols**

The Storytelling-Questioning protocols can be found in Appendices A-D. The text of the story can be seen in the underlined portions and the questions associated with these pages can be seen in italics. In terms of the questions designed for each story, several ideas guided their development. Since the purpose of this work was to engage students in informal inferential reasoning, questions were first designed to target each of the three components of IIR: making inferences about a population based on a sample, expressing their uncertainty or certainty, and relying on data in doing so (Makar & Rubin, 2009). These questions took the general form of, “What do you think if …?” “What makes you say that?”, and “How sure are you that you will be right?” with the intention that they get students to make inferences, to express what motivated their thinking, and to address their level of certainty with regard to their inferences.

Another important principle that guided the development of the questions was that the questioning should happen at various points during the story as opposed to after the story was completed. There are three reasons for this. First, Johnson and Smith (1981)
found that young students were less able to make inferences when they were required to
draw upon different areas of the story at once; however, they were able to infer when all
the necessary information was in close proximity. Second, asking a question
immediately within the story allows for the context of the story to play a prominent role
and is a natural component of good storytelling. There is a danger of the context of the
data fading away by the end of the story. Finally, and most obviously, if inferences are
ever going to be tied to the plot of the story, then those questions naturally have to occur
before the story is resolved.

Selecting moments of discourse and debate was done with an eye towards several
factors. The most important of these was identification of places where the intended types
of IIR questions could be asked. Overall, sections where data were explicitly referenced
in the text or the visuals were candidates for these moments provided the data could be
thought of as a sample of a larger population that was accessible to students. In each case,
the moments also provided students with the opportunity to utilize both textual and visual
data. Moments were not selected to be at the very start of the story since the context
would not have been sufficiently established yet. Finally, practical concerns guided the
selection as well in that the four moments were spread out throughout the text so that
students would not get weary of too much consecutive discussion or lose focus on the
story.

This approach is also consistent with recommendations for storytelling from
Zazkis & Liljedahl (2009) who say that feeling the audience, engaging the audience, and
responding to the audience are essential components of storytelling. Although many
questions were scripted, this process cannot always follow a script. The Storyteller-Questioner's role is viewed consistently with other researchers that have studied using stories for mathematical purposes. Roberts & Stylianides (2012) used stories to teach young students about parity and they described the goals of the teacher (who was responsible for conducting the intervention) in their study as, presenting problem-solving situations, encouraging mathematical discussions, modeling mathematical thinking through storytelling, and expecting children to provide explanations.

The content of the Storytelling-Questioning Protocol drew upon these goals in an important way. The Storyteller-Questioner made sure that the children had clear opportunities to provide both claims and associated justifications by asking, “What do you think about that?” or, “Why do you think that?” These questions accompanied nearly every student claim. As the Storyteller-Questioner, the researcher used these types of questions to get information about the reasoning of students, but also to encourage discussion of statistical ideas.

**Data Analysis**

**First Steps of Analysis**

Eisenhart (1988) describes the analysis phase of ethnographic research as consisting of a process of defining meaningful material, categorizing like units, and comparing categories looking for patterns. This reflects the general approach to data analysis used in this study. For this study, the video enhanced audio transcripts were used to answer each of the research questions. Field notes were created to help the researcher
make sense of the role, responsibilities, and decisions of the researcher/storyteller.

Collecting this type of data served to control for researcher bias.

The coding of the transcribed data was done in several phases using the Atlas.ti software with the first phase of analysis being completed on the questions that teachers asked during the recorded teacher observations. This analysis was done by attaching the component(s) of IIR that each question was addressing to the teacher question. In instances where no IIR component was addressed, no code was given. This served to quantify the amounts of opportunities the teachers gave to reason with aspects of IIR.

For the storytelling-questioning episodes, all questions asked by the researcher were coded. These were coded with a number followed by a “Q”. These researcher questions were coded with a number in order to make connecting the questions to their associated student responses easier. For example sentences coded 4Q and 4C represent question #4 asked by the researcher and the claim that was made in response to question #4. This leads to coding for the student responses.

The unit of analysis for the student responses was at the utterance level where an utterance was considered to be a complete thought by a student. Thus, one particular student utterance often consisted of several sentences. On the other hand, at times students responded with, “Yeah” or “Maybe” or “I think so.” These also accounted for complete utterances provided no more explanation of those sentiments followed. This utterance variation was necessary in order to capture both the complexity of student reasoning as well as the times when students had a reaction to an idea but were unable or not asked to explain their thinking further. Student responses involved claims made in
response to questions, support or rationale for particular claims of their own or of others. These categories made up a bulk of the codes in this area. In some instances student responses to questions were completely unrelated to the questions asked. These cases were coded 1NS to indicate statements that were irrelevant to the question asked. Table 3.4 represents the codes for claims and supports that were used as a first way to sort through and organize the data.

Table 3.4

*Initial Coding of Student Responses*

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1C</td>
<td>A student claim that is meant to answer question 1Q</td>
</tr>
<tr>
<td>1S</td>
<td>An original statement of support/rationale connected to question #1</td>
</tr>
<tr>
<td>1SC</td>
<td>A counter support/rationale provided for a given support/rationale connected to question #1</td>
</tr>
<tr>
<td>1SS</td>
<td>A supplemental support/rationale provided for a given support/rationale connected to question #1</td>
</tr>
<tr>
<td>1NS</td>
<td>An irrelevant statement provided and given in place of a support/rationale connected to question #1</td>
</tr>
</tbody>
</table>

The next step in the coding process is based on the framework from Makar and Rubin (2009) described earlier in Table 2.1 and is meant to look for IIR directly. All of the questions (from both the researcher and the teacher), claims posed by researcher and students, and supports provided by students that were coded in the previous step (e.g. 1Q, 1C, 1S) were then coded for their attention (or not) to the aspects of IIR. These include making or evaluating an inferential claim, explicitly relying on data, and attending to uncertainty. The questions, claims and supports were double or even triple coded.
provided that item addressed multiple aspects of IIR at the same time. It was also the case that sometimes the questions, claims, or supports did not attend to an aspect of IIR. In these cases, no code associated with IIR was given. Coding the transcripts based on question, claim and support, and IIR component essentially collected the statements from the transcripts into “bins” that could each be examined more closely in subsequent rounds of analysis.

Students exhibiting a high level of skill with IIR would be explicitly and appropriately relying on data to justify their inferential claims. To better understand how students reasoned in this way with highly contextual data as well as to understand the role that the story and the questions played in this reasoning, the support statements made by students (e.g. 1S, 1SC, 1SS) were coded, first to characterize the type of data that students were relying on in order to support their claim. Table 3.5 illustrates the codes developed for this purpose based on the pilot study which identified the types of evidence students relied on when they made their inferences (Smith, 2013). To capture the grade level of the students, K, 2, or 4 was appended to the code (e.g. EXTX-2 or IMTX-4). This helped separate the various coded items based on grade for purposes of making comparisons both within and across grades and for postulating about a developmental progression of ideas related to IIR.
Table 3.5

*Codes for Statements of Support*

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTX</td>
<td>Relies on explicit textual information from the story</td>
</tr>
<tr>
<td>EXVI</td>
<td>Relies on explicit visual information from the story</td>
</tr>
<tr>
<td>IMTX</td>
<td>Relies on implied textual information from the story</td>
</tr>
<tr>
<td>IMVI</td>
<td>Relies on implied visual information from the story</td>
</tr>
<tr>
<td>ADCX</td>
<td>Relies on student-added contextual details (not explicitly personal)</td>
</tr>
<tr>
<td>PECX</td>
<td>Relies on personal experiences with the context</td>
</tr>
<tr>
<td>NOEV</td>
<td>Does not rely on evidence or unable to express the evidence</td>
</tr>
</tbody>
</table>

The codes in Table 3.5 are meant to describe the different kinds of data that the students relied on when they described why they thought the way that they did. One of these types of data is explicit textual (EXTX) information from the story. This is information that is stated in the text of the story directly. Implied textual (IMTX) information was used when the story only implied information through the words of the story. Information in the story was considered to be explicitly visual (EXVI) when the information was shown through a picture and that information was the focus of the picture. If there were elements of the visuals that were not the focus of picture or were implied but not directly shown, then students were said to rely on implicit visual (IMVI) information. The next two types of information are directly centered on context. They are student-added contextual details that are not explicitly personal (ADCX), and student-added contextual details that are explicitly personal (PECX). In the second case students
explicitly refer to contextual elements that they have experienced. The final code was for instances where students did not rely on evidence (NOEV) of any sort or could not express what evidence they were relying on.

After this coding was completed, the next step was to look for patterns in the coded data that were relevant to each of the research questions. This was done through the tools provided by Atlas.ti, which allowed for sorting and mapping of codes as well as tabulating counts and percentages. It is important to understand that this aspect of the analysis was emergent and involved additional steps of coding as new and interesting aspects of the data were found. The IIR codes, when coupled with the Support codes, enabled the researcher to begin to characterize IIR both within and across grade levels. This emergent analysis initiated the next phase in the data analysis process.

**Emergent Analysis**

For each grade level the data was initially examined for patterns around the various components of IIR. These patterns were sought both within each grade and across the three grades. This was done in an effort to describe how students at different grades make inferences, rely on data, and attend to uncertainty. The analysis plan for examining students’ statements of support and whether those statements were relying on data has been discussed in the previous section but this leaves two more components of IIR, making or evaluating claims and attending to uncertainty, for examination.

One of the most fundamental ideas of this study was that young students would be able to engage in making and evaluating inferences when prompted to do so within the context of storytelling. The students were asked explicitly to make inferences based on
data at several moments when discourse and debate was encouraged within each story.

The responses students provided to these requests were categorized using the codes in Table 3.6. The codes were used to determine whether or not students were engaged in genuine inference-making or whether they were evaluating others’ inferences when specifically asked. This was done in order to understand if the storytelling-questioning approach was capable of engaging elementary school students in this way.

Table 3.6

*Codes for Making or Evaluating Inferential Claims*

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORI</td>
<td>Original Inference</td>
</tr>
<tr>
<td>AAI</td>
<td>Agreement with Another’s Inference</td>
</tr>
<tr>
<td>API</td>
<td>Abandoning or Countering a Previous Inference</td>
</tr>
<tr>
<td>NIR</td>
<td>Non-Inferential Response</td>
</tr>
<tr>
<td>IDK</td>
<td>No Response / I don’t know</td>
</tr>
</tbody>
</table>

The first three codes in Table 3.6 represent instances where students made or evaluated an inference in response to a question asking them do so. In these cases students provided either an original inference (ORI), expressions of agreement with another’s inference (AAI), or they abandoned their own previous inference or countered another’s inference (API). It was important to identify instances of agreement or disagreement with past inferences using separate codes as they involved different methods of engaging in inferential reasoning. The final two codes from Table 3.6 represent cases where students did not or were not able to make or evaluate an inference.
when prompted. These cases represent instances where students provided a response that was not an inference (NIR), cases where students did not respond, or cases where students responded only with, “I don’t know” (IDK).

Collecting the cases in which students made an original inference, agreed with a previous inference, or countered a previous inference provides a picture of how often students were able to make or evaluate inferences when asked to. However, while examining the data it became apparent that there were some instances where students were agreeing with other or countering others statements because they felt that they needed to provide an answer and certain types of answers are easy to provide. Some students seemed to be thinking, “I don’t know what to say so I will agree with the other students” or, “I don’t know what to say so I will say something close to what the other students have said.” At the moment these kinds of statements are being counted as genuine instances of inference-making or evaluating. However, these are very weak instances of engaging in IIR provided they can be considered instances of engagement at all.

To help create a more conservative estimate of the amount of times that students were engaged in genuine inference-making, the supporting statements that students made in regard to their claims were connected to student inferences. For all student inferences coded, these were categorized by whether the students provided a unique supporting statement to accompany it or not (e.g. Unique Support or No Unique Support). The thinking behind this was that if students were agreeing or countering another’s inference and could not or did not provide a unique support for that thinking, then they may not
have been genuinely engaged in inference-making, they may have only been providing a response because they felt that they needed to. By attaching codes that identified whether support was provided or not for the inferential claims made, and then removing those claims without a unique support, a conservative estimate could be reached to describe the number of instances in which students were very likely engaged in genuine inference-making or evaluating.

The coding discussed thus far covers students’ statements of support relying on data as well as covering students’ abilities to make or evaluate inferences. In order to analyze the third IIR component of attending to uncertainty, the student statements that were coded as attending to uncertainty were collected together and examined as a group. These statements were examined for patterns. The researcher field notes contained initial impressions of differences between grades and helped to inform the emerging codes. These ideas served as the starting place for this aspect of the analysis and provided four large categories of codes: certainty, probabilistic language, numerical chances, and complete uncertainty that describe the various ways in which students attended to uncertainty, namely, “How sure are you that what you infer will actually happen?” Within these four main categories (which will be explained in more detail after Table 3.6) their contents were unpacked further according to the different rationales that accompanied students’ expressions of uncertainty in the data. These rationales fit into three subcategories. In some instances students did not provide an accompanying rationale for their statements attending to uncertainty. In other cases students’ thinking about uncertainty was informed by the data. Finally in some cases the students’ rationale
was based on the fact that they were reasoning within a story context where there were assumed rules for stories and storytelling. All of the codes pertaining to attending to uncertainty are shown in Table 3.7.

Table 3.7

*Codes for Attending to Uncertainty*

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>Certainty - General</td>
</tr>
<tr>
<td>CTS</td>
<td>Certainty – Used Story</td>
</tr>
<tr>
<td>CTD</td>
<td>Certainty – Used Data</td>
</tr>
<tr>
<td>PL</td>
<td>Probabilistic Language - General</td>
</tr>
<tr>
<td>PLS</td>
<td>Probabilistic Language – Used Story</td>
</tr>
<tr>
<td>PLD</td>
<td>Probabilistic Language – Used Data</td>
</tr>
<tr>
<td>NC</td>
<td>Numerical Chances - General</td>
</tr>
<tr>
<td>NCS</td>
<td>Numerical Chances – Used Story</td>
</tr>
<tr>
<td>NCD</td>
<td>Numerical Chances – Used Data</td>
</tr>
<tr>
<td>CU</td>
<td>Complete Uncertainty – General</td>
</tr>
<tr>
<td>CUS</td>
<td>Complete Uncertainty – Used Story</td>
</tr>
<tr>
<td>CUD</td>
<td>Complete Uncertainty – Used Data</td>
</tr>
</tbody>
</table>

The codes from Table 3.7 represent the ways in which the students in this study expressed how certain they were about the inferences that they, or others, made. Students were either certain that what they inferred would happen would actually happen, completely uncertain of what might happen by acknowledging that any inference could happen, or they expressed some gradation of likelihood in between. The differentiating
characteristic between these statements that expressed varying degrees of likelihood in the middle was that they were either using informal probabilistic language (e.g. Probably, Likely, Might, Most likely, Maybe, Could be, Most of the time) or they were moving towards a numerical expression of probability (e.g. 8 out of 10 times, about half of the time, 1 in a million chances, about 10% of the time).

The subcodes of “Used Story” and “Used Data” were used to capture the times when students expressed their position on uncertainty and then gave a rationale for that judgment that was either based on the data or based on the story. The subcode “Used Data” was used when students made statements like, “I think that _____ will definitely (or definitely not) happen because of _____” and relied on the data from the story saying that their inference was certain or likely to happen because of information from the text, visuals, or context of the story. The subcode “Used Story” was used when students provided rationales about particular things that must or must not occur because there are particular rules or expectations for things that happen or do not happen in stories. Student statements that did not provide direct evidence of “Data” or “Story” were placed into the subcode “General”.

Analysis of Storytelling-Questioning

This phase of analysis was also emergent based on the different categories of data collected and by patterns that surfaced from the coding already discussed in the first steps of the analysis. The two research questions in this study generally focus on describing the IIR of elementary school students and the impact of the Storytelling-Questioning approach on students’ engagement with IIR. To examine the Storytelling-Questioning...
approach in more detail, the questions teachers asked, the questions the researcher asked, and the stories utilized were each analyzed. As discussed earlier in the “First Steps of Analysis” section each question that was asked by the researcher was coded with a “Q” and this collection was the subject of analysis.

To analyze the teacher observation data, as discussed above each teacher question was coded based on the IIR component(s) that it attended to. Each of the teacher questions that attended to one of the aspects of IIR were collected into a table to search for emergent patterns. From examining these questions two relevant characteristics stood out and were used to code the questions: whether or not the IIR questions that teachers asked were centered on the plot of the story and whether or not students were asked to focus on categorical or numerical data. These two characteristics were distinguishing characteristics, along with the number of questions attending to IIR, between the teachers’ questions during storytelling and the Storytelling-Questioning approach.

The purpose of most of the questions asked during the Storytelling-Questioning episodes was to elicit the students’ current IIR abilities. As such, it is important to understand if particular types of questions impacted whether students engaged in the three aspects of IIR or not. For this reason, it was important to connect the questions asked to the kinds of responses that students gave. In order to do this first, questions were identified that resulted in strong engagement with IIR. Strong engagement was defined as segments where at least one of the three students in a group engaged in all three components of IIR in response to a single question or a series of related questions and the other two students engaged with at least two out of the three components of IIR. After
these were coded, these questions were collected together and examined for patterns and themes. This resulting group of questions represents all of the researcher questions that helped to elicit students’ engagement with all three parts of IIR.

It was not only important to examine the questions that were able to elicit IIR, but it was also important to examine instances in which the students’ responses were irrelevant or were simply, “I don’t know.” Weak engagement with IIR was defined as instances where all three students either said they didn’t know or provided irrelevant responses when asked to attend to at least one of the three IIR components or instances where each student struggled with at least one component of IIR. In these cases particular students were not able to engage in any part of IIR in response to the questions asked. After these were coded, these questions were collected together and examined for patterns and themes. Of special note was the contrast between the questions that elicited “Complete IIR Responses” and those that elicited “No IIR Response.”

As a final detailed bit of analysis of the questions asked, two special cases of questions were analyzed. Pulling apart these situations held potential for understanding if these specific kinds of questions were affordances, constraints, or neither in light of the goals of Storytelling-Questioning. The first kind of question was the generic set-up questions like, “What are you thinking about now?” One particular excerpt of a transcript was examined as a case study of this type of question. The second specific type of question worth more detailed examination was the “Extreme Cases” type question where the researcher asked, “What if I said that I think that ________ will happen?” In a majority of these cases this type of question asked students to confront an inference that
was extremely unlikely. Again, a particular excerpt was extracted and described to serve as an exemplar for the impact of this type of question.

**Analysis of Stories**

Following the analysis of the questions in light of IIR, further exploration of Storytelling-Question was done through the examination of the stories. The stories were analyzed in a similar fashion to the analysis of IIR. Where the IIR-related tables covering inference-making, support and rationales, and attending to uncertainty discussed above were separated based on student grade, the same tables were created but separated by individual story. So, tables illustrating students’ ability to make or evaluate inferences (Original, Agreement, Counter, Non-Inferential) and the rationales for inferences (Explicit Textual, Implicit Textual, Explicit Visual, Implicit Visual, Non-Personal Context, Personal Context, No Evidence), and attending to uncertainty (Certainty, Probabilistic Language, Numerical Chances, Uncertainty) were each separated across the four stories, *June 29, 1999, Miss Malarkey Leaves No Reader Behind, Sylvester and the Magic Pebble, and Nothing Ever Happens on 90th Street*. As with the analysis of IIR, patterns and themes were examined and explained based on these tables.

This analysis was followed by a description of the kinds of contexts that students were utilizing from the story settings. Each of the statements coded as Non-Personal Context or Personal Context, were examined and the relevant contexts that students were using in these cases were collected and tallied. This provided a sense for the number of times particular story contexts were relied on by students.
In a final bit of analysis of the stories and storytelling, two short vignettes illustrate two unique ways in which there was development in students’ language abilities to speak about IIR and growth in understanding the patterns and expectations of operating within Storytelling-Questioning. These two cases were brought forward because of their uniqueness and their potential to hint at long-range benefits of the Storytelling-Questioning approach.

**Standards for Naturalistic Research**

Credibility refers to the truth value of a study (Moschkovich & Brenner, 2000). This study established credibility in two ways. First of all, this methodology utilized triangulation of data. Three different data sources contributed to this work: audio data, video data, and researcher field notes. Additionally over the course of this study, around 12 hours of data were collected, transcribed and analyzed. This amount of data allowed for digging deeply and nuanced analysis which produced the results contained in Chapter 4. The many levels of coding and analysis also demonstrate that the analysis was extensive.

Transferability refers to the applicability of a study (Moschkovich & Brenner, 2000). In this study transferability will be achieved by focusing both on student understanding and teacher instructional methods. One outcome of this study will be the approach of Storytelling-Questioning that teachers will be able to utilize within their classrooms. Transferability will also be achieved through the use of thick descriptions which will consist of a description of context and of what occurs within that context. This
will allow others to decide on the transferability of this work given the similarity of this context to their own.

Dependability refers to the consistency of a study (Moschkovich & Brenner, 2000). Dependability of this study was established by using multiple recording devices to capture data. This allowed for the greatest chance of capturing everything that occurred within this research setting. For example, the video data captured students’ gestures thus providing a more complete view of what occurred.

Confirmability refers to the neutrality of this study (Moschkovich & Brenner, 2000). This was established by carefully defining the researcher's role as a participant-observer. The researcher's role was defined by two major components. First, the Storytelling-Questioning Protocol scripts the sorts of questions that the researcher posed. This was not a static, immovable script determining the interaction but rather a guideline of major points to hit and major patterns of questioning. Second, in order to monitor the researcher's role during these more open and flexible moments, the storyteller/researcher took field notes which reflected his experiences and his decision-making during the storytelling episodes.
RESULTS

Research Question #1

The first research question for this study was, “What does Storytelling-Questioning reveal about the similarities and differences in students’ Informal Inferential Reasoning both within and across grades K, 2 and 4?” The results presented below are divided by the IIR components. Occurrences of students making or evaluating inferential claims, expressing what their inferences were built upon and providing supporting rationales, and students addressing the inherent uncertainty in making or evaluating inferences were sorted and examined to address this research question based on the analytical methods discussed in Chapter 3.

IIR Component 1: Making or Evaluating Inferences

On the most fundamental level, it was hoped that this study would establish that elementary school students were able to informally create inferences when prompted within the context of storytelling. As described in Chapter 3, codes were created to help describe if students were engaging in inference-making or not. Table 4.1 is divided into these two categories and contains the results from the analysis of students’ inferences. This table shows the percentage occurrence of each kind of response by grade level.
Table 4.1

Making or Evaluating Inferences

<table>
<thead>
<tr>
<th></th>
<th>Making or Evaluating Inferences</th>
<th>Non-Inferential</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Original Inference</td>
<td>Agreement</td>
<td>Abandoning or Countering a Previous Inference</td>
</tr>
<tr>
<td>K</td>
<td>37</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>42%</td>
<td>16%</td>
<td>27%</td>
</tr>
<tr>
<td>2nd</td>
<td>47</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>53%</td>
<td>18%</td>
<td>23%</td>
</tr>
<tr>
<td>4th</td>
<td>35</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>43%</td>
<td>37%</td>
<td>18%</td>
</tr>
</tbody>
</table>

**Within the Grades.** Several interesting trends appear in this table. By examining the results for Kindergarteners, one can see that after providing an original inference Kindergarten students were most likely to abandon or counter a previously made inference. This occurred at a rate of 27% compared to a 16% rate for agreeing with another’s already stated inference. Together these categories total 85% of their coded responses that were characterized as inferential. The remaining 15% of the Kindergarten students’ responses were non-inferential. For second graders the most frequent way of engaging in inference-making after providing original inferences was also to abandon or counter a previous inference. This occurred 23% of the time while the instances of agreement occurred 18% of the time. The most prominent feature of the characterization of the fourth grade responses was that while 43% of their responses were original inferences, after that, fourth graders engaged with these ideas by agreeing with an already
stated inference 37% of the time. Additionally of note, 98% of the fourth graders’ responses were inferential.

Across the Grades. The first main finding across these three grades is that overall, elementary school students are able to make or evaluate inferences utilizing the Storytelling-Questioning approach designed for this study. In short, students of this age are capable of engaging in this way in this environment. The Kindergarteners, second graders, and fourth graders responded to questions asking for inferences by providing inferences or evaluating inferences either of their own design or by reasoning about another’s inferences; this occurred 85%, 94% and 98% of the time respectively. This represents a large portion of student statements that where essentially “on-topic” and is significant enough to demonstrate that these students were capable of engaging in this kind of thinking.

With that said, it may be appropriate to suggest a more conservative description of the amount of actual inference making occurring, especially given the nature of the instances of agreement. Both the field notes and analysis of the video data brought to light that occasionally when students were unsure of how to respond to the researcher’s questions, they seemed to just agree with an inference that was already made. They may have been thinking, “I’m not sure what to say, so I’ll just agree with what that person said.” This type of thinking is not strong inference-making, even though agreeing with someone else in other cases could be a genuine inference. Therefore, if all of the responses coded as “agreeing with another’s inference” are eliminated, a more conservative description is obtained by subtracting the entire percentages representing the
agreement category. Doing this shows that 69% of Kindergarten, 76% of second grade, and 61% of fourth grade responses could be conservatively called genuinely inferential in nature.

Beyond the instances of inference-making, there were also some “off topic” remarks made that were coded as “non-inferential.” To illustrate this, consider the following interchange with a Kindergarten group using the story, *June 29, 1999*:

I: So we have seen a lot of different vegetables. What kinds do you think that we will see next?
S1: I want to be in all these countries. [Referring to the different places in the story]
I: Yeah.
S3: I want to be in that country with the plane. [Referring to the picture of a plane]
S2: I don’t even know what artichokes taste like, but I wouldn’t even like them.

Clearly these responses were not addressing the question asked and were not inferences. However, this type of interaction is normal both for students of this age and for discussions that occur within a story. When these “off-topic” responses were redirected by either repeating the question of concern or restating it with slightly different language, students were able to refocus. Overall, 41% of the non-inferential statements were redirected so that the students eventually engaged in inference-making. The above instance is one such successful example. Directly after the excerpt above, the focus question was just repeated resulting in the following interchange:

I: What kind of vegetables do you think that we will see next?
S2: Umm space vegetables?
S1: Spinach, broccoli, cucumber…no we already saw cucumbers.
S3: Spinach, yummy. Maybe tomato.
In this case the three students were each able to make an inference in response to the question asked for a second time.

Another point related to the data in Table 4.1 involves the second graders’ tendency to respond with original inferences at a higher rate than the other grades. 53% of second graders’ responses fell into this category compared to 42% and 43% for Kindergarteners and fourth graders respectively. This result mirrors some of the findings that will be discussed in the upcoming section on attending to uncertainty. Together these facts help to show that second graders seemed to interact with IIR in a particularly unique way.

The final major pattern resulting from Table 4.1 concerns the differences between the approaches of students from each grade when it came to either agreeing or countering other’s inferences. Kindergarteners engaged with inferences more often by abandoning or countering an already stated inference than they did by agreeing with an already stated inference. In fact, these two categories of inference-making seem to be inversely related. The Kindergarteners contrast with the second and fourth graders, who were more and more likely to agree with other’s inferences, while the rate of abandoning and countering inferences was shown to be less and less across the grades. The rate of 27% for instances of abandoning or countering among Kindergarteners is higher than the rates for the second graders and fourth graders which were 23% and 18% respectively. The excerpt below shows typical examples of these two occurrences. This excerpt comes from a Kindergarten group working with the story June 29, 1999:

I: Do you think that these are her vegetables that are floating down?
S1: Yeah.
S2: Um, yeah.
I: Why do you say that?
S1: Because she was like floating vegetables and they might have grown already.
I: They might have grown. What do you think? Do you think that these are her vegetables?
S2: [shakes head no]
I: Why do you think No now?
S2: Because she didn’t plant those. Usually sometimes in a book it is like that and you think it is her vegetables but in the end sometimes it is not.

In this case S2 originally thought that the vegetables floating down from the sky belonged to Holly, the main character. However S2 abandons her original thought and counters the rationale provided by S1.

In contrast, the following transcript comes from a group of fourth graders engaging with the story *Nothing Ever Happens on 90th Street*:

I: If we meet 10 more people, how many of them do you think would be female and how many of them male?
S1: I bet, I think more female maybe since so far we have seen more female. Or maybe more male. Male.
S2: Yeah.
I: You think more male?
S3: I think more females.
S2: Well, possibly more male, because lots of females came and then only three males including him. So possibly there are a lot more men that could come.
I: Yeah, what do you guys think of that?
S3: Yeah.
S1: Yeah, maybe.
S3: Maybe.

In this case, S1 and S3 at the end of this exchange end up agreeing with the inference that S2 makes which is accompanied by a rationale. This agreement was in spite of S1 possibly thinking differently at the start of the excerpt. This type of agreement following a presented rationale was typical.
IIR Component #2: Support for Inferences

The second aspect of IIR is the ability to explicitly refer to the data that an inference is built upon. Analyzing these statements amounts to analyzing the statements of support provided by the students in connection with the inferences that they made. Table 4.2 attempts to connect these ideas, the inference statement and the support that goes with it. Similarly to the issue discussed above in regards to classifying the agreement responses, the uniqueness of the supporting statement matters. Just as some instances of agreement could actually represent a cover for genuine cases of “I don’t know,” providing a non-unique response that is very close to a previous one could represent that same kind of thinking. In other words, a student may be thinking, “I don’t know, so I will just say what they said or at least something close to what they said.” Therefore, it was necessary to examine the supports/rationales that accompanied the student inferences in order to further identify genuine instances of inference and to serve as a gateway for talking about the details of the rationales.

This examination was done in two ways. First, it was determined if students were able to provide a unique expression of support for their inference. If they were, it would be reasonable to assume that they were genuinely engaged in the first component of IIR. To quantify this, all student inferences from the original three categories of inference, agreement, and counter-inference were collected and connected, if possible, to a unique expression of a rationale for their thoughts. Therefore, this identification of unique support merely posits the existence of said support. Second, the content of these support
statements was analyzed to characterize the ways in which students supported their inferences.

**Uniqueness of Support.** To illustrate the identification of unique support for inferences, consider the following excerpt from a second grade group working with Sylvester and the Magic Pebble.

I: …Let’s say that he looked through 30 pebbles before he found this one. If he looked through 200 more pebbles how many magic pebbles do you think that he would find?  
S1: Maybe 10.  
…  
I: Uh-huh. Is that what you were thinking? You said 10 at the beginning.  
S1: Could be one or two.  
I: Could be one or two?  
S1: Well he has one now. He could find that one.

In this excerpt, S1 originally said that Sylvester would find 10 more magic pebbles. Later (after two other students made and explained their inferences), S1 was asked to explain his inferential claim. He abandoned his original claim and made a new claim (“Could be one or two”) and then provided unique support for that new claim (“Well he has one [magic pebble] now. He could find that one”).

The overall results on the uniqueness of the support provided in each grade are shown below in Table 4.2.
Table 4.2

Extent to Which Unique Support was Provided for Inferences Made or Evaluated

<table>
<thead>
<tr>
<th>Making or Evaluating Inferences</th>
<th>Original Inference</th>
<th>Agreement with Another’s Inference</th>
<th>Abandoning or Countering a Previous Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unique Support</td>
<td>No Unique Support</td>
<td>Unique Support</td>
</tr>
<tr>
<td>K</td>
<td>22</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>59%</td>
<td>41%</td>
<td>36%</td>
</tr>
<tr>
<td>2nd</td>
<td>26</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>55%</td>
<td>45%</td>
<td>38%</td>
</tr>
<tr>
<td>4th</td>
<td>23</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>66%</td>
<td>34%</td>
<td>37%</td>
</tr>
</tbody>
</table>

There is one very striking finding across the three grades. An overwhelming proportion of instances when students were abandoning, countering, or agreeing with a given inference was not supported uniquely as in the example provided above. In each of these cases, across all of the grades, the percentages were close to 60%, showing that students were not providing unique supports a majority of the time when abandoning, countering, and agreeing with inferences. Therefore, it is questionable whether students were genuinely engaged in inference-making when they were abandoning, countering, or agreeing with a given inference. To illustrate this, consider the following example from a fourth grade group working with Nothing Ever Happens on 90th Street:

I: If we meet 10 more people, how many of them do you think would be female and how many of them male?

...  
S2: Well, possibly more male because lots of females came and then only three males including him, so possibly there are a lot more men that could come.
I: Yeah, what do you guys think of that?
S3: Yeah.
S1: Yeah, maybe.
S3: Maybe.

In this example both S3 and S1 state their agreement with the inference and rationale put forward by S2; however, when given the opportunity, they did not expand upon their agreement with supporting statements. In this case, S3 and S1 may have genuinely been coming to the same conclusion as S2, but without an explicitly stated rationale it is difficult to tell.

Another excerpt illustrating the abandonment of a previous inference for a new one without support comes from a Kindergarten group working with the story *June 29, 1999*. Prior to this excerpt S1 said that he thought that the next turnips to fall from the sky would be the size of 14 boulders and S2 and S3 agree with this without providing any support for their inferences.

I: Yeah. And what do you guys think?
S3 and S2: Same.
I: Yeah, you guys think the same. Are you guys sure that it would be the size of 14 big boulders?
S2: [nods yes]
I: What makes you so sure?
S2: I don’t know.

There was no evidence that S2 was engaged in inference-making, because he only said, “Same,” and “I don’t know” when probed.

Given these findings, it may be the case that the occurrence of making or evaluating inferences across the grades (74%, 75% and 85% of the time for grades K, 2 and 4 respectively) may actually still be over-estimates. More accurate percentages that
do not include instances where students did not provide unique support for their agreement, abandoning, or countering would be 47% (35 out of 75) for Kindergarten, 49% (41 out of 83) for second grade, and 50% (40 out of 80) for fourth grade.

**Content of Support Statements.** While students did not provide support for their inferences the majority of the time, there were still many instances where the actual content of their support statements could be analyzed. The analysis of that content showed that students relied on six different types of support for their statements, as shown in Table 4.3. The first four categories represent a reliance on either textual or visual data from the story, while the next two categories represent relying on outside information. The final category represents irrelevant supporting rationales or rationales that could not be deciphered.

Table 4.3

**Supporting Inferences**

<table>
<thead>
<tr>
<th></th>
<th>Explicit Textual</th>
<th>Implied Textual</th>
<th>Explicit Visual</th>
<th>Implied Visual</th>
<th>Non-Personal Context</th>
<th>Personal Context</th>
<th>Irrelevant Support</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>9</td>
<td>3</td>
<td>15</td>
<td>6</td>
<td>11</td>
<td>9</td>
<td>16</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>13%</td>
<td>4%</td>
<td>22%</td>
<td>9%</td>
<td>16%</td>
<td>13%</td>
<td>23%</td>
<td>100%</td>
</tr>
<tr>
<td>2nd</td>
<td>15</td>
<td>1</td>
<td>16</td>
<td>5</td>
<td>15</td>
<td>12</td>
<td>13</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>19%</td>
<td>1%</td>
<td>21%</td>
<td>6%</td>
<td>19%</td>
<td>16%</td>
<td>17%</td>
<td>100%</td>
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<tr>
<td>4th</td>
<td>13</td>
<td>5</td>
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<td>3</td>
<td>17</td>
<td>2</td>
<td>3</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>8%</td>
<td>33%</td>
<td>5%</td>
<td>26%</td>
<td>3%</td>
<td>5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Within the Grades.** If you combine the two context categories together (for a 29% occurrence total), this represents the most significant way Kindergarteners supported their inferences. This is closely followed by a reliance on explicit visual data,
which occurred at a rate of 22%. Finally, Kindergartners also used explicit textual data from the story at a 13% rate. Below are three excerpts to illustrate the main ways Kindergartners supported their inferences. First is an excerpt from Miss Malarkey Leaves No Reader Behind. This example illustrates the use of personal identification with the context.

I: Okay. Now, What if I said that I think that all 20 [students in another class that joined those already in the cafeteria] will be girls? [All laugh]
... 
S2: I say no way!
...
I: Why do you think that there would be some boys and some girls?  
S2: I wouldn’t want to be in a class of all girls. I’d feel sorry for that boy.

In this example, S2’s rationale as to why all 20 incoming students could never be all female was that he would not want to be in a class of all girls. S2 is identifying with the context of the school and classrooms in a personal way by interjecting himself into the context and reasoning from there.

The next excerpt from the same point in the story illustrates the use of explicit visual information.

I: Yeah well, if I were to say that another 20 students came in, how many of them do you think would be reading?  
S1: 4 
...
I: Yeah, what makes you say that?  
S1: Because there are 4 books here. One. Two. Three. Four. [points to book and counts them out]
I: Oh. So you think that since this class has 4, the other class will do 4 also?  
S1: Yeah.
Many students are shown in this book sitting in a cafeteria eating, talking, and reading. In fact, there are exactly 4 students in this particular cafeteria reading books. So, when asked how many would be reading if a different class of 20 students were to come into the cafeteria, S1 pointed to the images on these pages and counted the number of readers pictured. S1 relied on this explicit visual information to make the inference that 4 students in the next class would be reading.

This last excerpt from June 29, 1999 provides an illustration of students relying on explicit textual information.

I: Do you guys think that these are Holly’s vegetables?
All students: yes.
I: Okay. Why do you think that?
S2: Well, all except for one of them.
I: Why except for one?
S2: Cause that is one that it says that she did not put in there. That might have been from somebody else in her experiment.

The last statement by S2 shows that she was relying on explicit textual information to make her inference. In this case, when S2 says, “Cause that is one that it says that she did not put there,” she is pointing to the text of the story where it says, “Holly is puzzled. Arugula was not part of her experiment.” Since the story explicitly states that arugula was not a part of Holly’s experiments, S2 uses that information to reason that all of the vegetables falling from the sky may not be Holly’s.

Second graders relied on context a total of 35% of the time with a roughly equal proportion of these being based on personal experiences, and non-personal understandings. After that, their primary means of support was to utilize explicit visual data, with a slight preference to that over explicit textual data. The following excerpt
illustrates how one second grader utilized a non-personal context to support her inference during an episode using *Sylvester and the Magic Pebble*.

I: Well, how many more [magic pebbles] could he find if he looked through 200? Is it possible that he would find none?
S1: Yeah, it is possible.
S3: [Agrees] Cause there are lots of pebbles out there and none of them are magic.

S3 was reasoning based on the context of finding pebbles by streams and notes that in the real world there are “lots of pebbles out there and none of them are magic.” This represents a use of context that was not explicitly personal, since S3 did not interject herself into the context. In other words, she did not say something akin to, “I have never found a magic pebble out there so it is certainly possible that Sylvester would not find another.”

The fourth graders preferred to rely on explicit visual data the most. This occurred at the highest rate (33%) even when comparing to the combined context categories. While they used non-personal contexts at a high rate (26%), there was very little use of personalized contexts (3%). A typical example of a fourth grader utilizing explicit visual information to support an inference comes from an episode of *Nothing Ever Happens on 90th Street*.

I:…What if I said that I think that she will definitely meet a barbershop person [on 90th Street]?
S1: Probably.
S3: Maybe.
S2: I would think so. If they showed it in the picture then they probably will.
S1: Maybe, but you can’t be sure because it looks closed.
S3: Uh-huh
In this case, both S2 and S1 are relying on the fact that a barbershop is clearly pictured in the book. This example also illustrates two different conclusions based on the same visual information. S2 essentially says that if it is in the story’s images, it will likely appear later in the story, while S1 focuses on more detail in the images concluding that the main character might not run into a barbershop person given that the barbershop seems closed.

**Across the Grades.** There are three strong trends that can be seen when comparing across grades utilizing Table 4.3. First is that the reliance on personalized context as a support for inference-making was strongest among the younger two grades at 13% and 16%, while only a small factor in the reasoning of the fourth graders at 3%. The younger students often interjected themselves into the situation and reasoned based on how they would react as in the Kindergarten except above where the student said that having a class of 20 girls would be impossible, because he wouldn’t want to be the only boy in a classroom full of girls.

The second trend in Table 4.3 that is apparent when looking across the grades is that as students get older the attention paid to explicit data increased. From Kindergarten to second grade to fourth grade the percentage of support statements relying on explicit visual information increased from 23% and 22% at the lower levels to 33% at fourth grade. With regard to the use of explicit textual data the increase was from 13% in Kindergarten to 19% and 20% in second and fourth grades.

The third trend in Table 4.3 is that across all grades students did not often utilize implied textual or visual information when justifying their inferences. Across all of the grades there were only 9 instances of relying on implied textual evidence and only
fourteen instances of relying on implied visual evidence. These instances will be discussed in further detail in the section on research question 2 as their occurrence seems tied to particular elements of the stories.

IIR Component #3: Attending to Uncertainty

The third and final IIR component to discuss is attending to uncertainty. The results on student responses related to uncertainty are summarized below in Table 4.4. Table 4.4 summarizes the different types of approaches for expressing uncertainty utilized across the different grades based on four general categories: certainty, complete uncertainty, probabilistic language, and numerical chances.

Table 4.4

<table>
<thead>
<tr>
<th></th>
<th>Certainty</th>
<th>Probabilistic Language</th>
<th>Numerical Chances</th>
<th>Complete Uncertainty</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>36 (47%)</td>
<td>28 (36%)</td>
<td>0 (0%)</td>
<td>13 (17%)</td>
<td>77 (100%)</td>
</tr>
<tr>
<td>2nd</td>
<td>37 (43%)</td>
<td>43 (49%)</td>
<td>0 (0%)</td>
<td>7 (8%)</td>
<td>87 (100%)</td>
</tr>
<tr>
<td>4th</td>
<td>27 (23%)</td>
<td>72 (61%)</td>
<td>15 (13%)</td>
<td>4 (3%)</td>
<td>118 (100%)</td>
</tr>
</tbody>
</table>

Within the Grades. Table 4.4 shows that each grade had a distinctive feature that stood out from students of other grades. Second graders basically attended to uncertainty in two ways. First, was by being completely certain that their inferences would be correct. 43% of the second grade responses fell into this category. In a vast majority of these cases, the inferences that they were certain about were their own. Most of the
student statements that fit into this category were of the basic form, “I think that ____
will happen and I am sure that it will.” This method of dealing with uncertainty was only
exceeded by the use of probabilistic language with such words and phrases as
“perhaps…” “maybe…” “not very likely…” etc. Nearly half of the second graders’
responses involved expressing uncertainty using these phrases.

Kindergarteners, on the other hand, operated on the extremes of the probability
continuum a solid majority of the time (64%). At times they seemed to be so uncertain of
what might happen that they frequently acknowledged that anything could happen.
Kindergarteners had the largest proportion of these types of responses. Kindergarteners
were also likely to give significant weight to their own inferences, with statements of the
form, “I think that ____ will happen and I am sure that it will”.

Fourth graders were the only group of students where a numerical sense of
probability or likelihood was present. This means that they recognized that some
inferences were more likely than others and that this difference could be expressed with
numbers. Many of the responses within this category were similar to the following
student responses, “Well, it is like it would happen 8 out of 10 times” or “It would
probably happen 50% of the time.” For instance when asked what they thought about my
[the researcher’s] inference that the next ten people that we would meet on 90th Street
would be male, one fourth-grade student responded “Maybe not, but maybe… only like
one out of 100 times.”

Analyses of the field notes taken during the Storytelling-Questioning episodes
showed that initial impressions align with these findings. Kindergarteners were described
as being overly certain, second graders as less uncertain, and fourth graders as utilizing numerical ideas of chance. Further discussion of these trends, along with accompanying examples, are provided in the next section.

**Across the Grades.** The main finding from Table 4.4 is that across all three grades there was a steady increase in the use of non-numerical probabilistic language to express some gradation of likelihood between absolute certainty and absolute uncertainty. For example, students said things like, “I would think so. If they showed it in the picture then they probably will [encounter a barbershop on the street]” or, “Well, probably 3 or 4 [people necessary to hold down a floating pepper]” or, “Maybe she would only read 4 [books], but like she could be like the boy [implying that she could read none].” In each of these cases students expressed some recognition that there was some likelihood that their inference would be correct that was neither completely certain or completely uncertain. Similarly the other categories showed clear trends across the grade levels with the use of numerical likelihood only within grade 4 and with the tendency to be completely uncertain decreasing as the grades advanced.

**Support for Statements about Uncertainty**

Table 4.5 summarizes the results when considering the rationales students used to support their statements about uncertainty. While the majority of the 282 statements about uncertainty were not supported, there were still 82 instances where rationales were provided (23 for kindergartners, 28 for second grade, and 31 for fourth graders. Within the four main areas of expressing uncertainty (certainty, probabilistic language, numerical chances, and complete uncertainty), there were two main ways students made their
judgments: 1) by utilizing data; and 2) by utilizing the context of the story and storytelling.

Table 4.5

*Attending to Uncertainty: Relying on Story or Data*

<table>
<thead>
<tr>
<th></th>
<th>Certainty Used Story</th>
<th>Certainty Used Data</th>
<th>Probabilistic Language Used Story</th>
<th>Probabilistic Language Used Data</th>
<th>Numerical Chances Used Story</th>
<th>Numerical Chances Used Data</th>
<th>Complete Uncertainty Used Story</th>
<th>Complete Uncertainty Used Data</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>1 (4%)</td>
<td>7 (30%)</td>
<td>3 (13%)</td>
<td>10 (44%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>2 (9%)</td>
<td>0 (0%)</td>
<td>23</td>
</tr>
<tr>
<td>2nd</td>
<td>4 (14%)</td>
<td>8 (29%)</td>
<td>4 (14%)</td>
<td>9 (32%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>2 (7%)</td>
<td>1 (4%)</td>
<td>28</td>
</tr>
<tr>
<td>4th</td>
<td>2 (7%)</td>
<td>6 (19%)</td>
<td>4 (13%)</td>
<td>14 (45%)</td>
<td>0 (0%)</td>
<td>5 (16%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>31</td>
</tr>
</tbody>
</table>

**Within the Grades.** The most distinctive feature about the Kindergarteners’ reasoning is the difference between when their decisions about uncertainty were based on data and when they were not. They used data most often in the probabilistic language category followed by expressions of certainty, where they also relied on data more frequently. For example, consider the following excerpt:

I: What if I said that I am sure that he would like all of them on the shelf?  
S2: [nods no]  
S1: I would say maybe, but I doubt it.  
S2: I would say maybe, but only that kind that he read.  
I: Well, you said maybe, but I doubt it. Why do you doubt it?  
S1: Because he is...because...because only in the end did he read a book. ‘Cause earlier in the story he was like, “Ugh.” Plus he was like, “I like my friends and I want to play video games with them.”
In this excerpt S1 was using probabilistic language to talk about the likelihood of an event in saying, “I would say maybe, but I doubt it.” At the end of the exchange he justifies this probabilistic language assertion by referring to some explicit textual data. This judgment about uncertainty was based on data from the story.

Kindergartners also used the storytelling setting as a basis for reasoning about uncertainty. The following is an example from a case when a student was completely uncertain:

I: …If he looked through 200 more pebbles how many magic pebbles do you think that he would find?
S1: Maybe 10.
S3: 20. 30. 40. 50. 60. 70. 80. 90. 100.
...
S3: Well, I think 0.
I: You think 0?
S3: Um…’cause, ’cause we knew that he had to get one…
I: For the story?
S3: Yeah.

Here S3 makes numerous different inferential claims without seriously considering an answer. This represents complete uncertainty, since he is communicating that anything could happen. The rationale that he gives for his thoughts involves the fact that this was a story. It is established in the story that Sylvester has to find one magic pebble and that is all, so he shouldn’t find any more. Yet based on S3’s inferences, anything could happen.

Second graders followed a similar pattern as the Kindergarteners. However, second graders relied on the fact that they were reasoning within a story more frequently, accumulating a total of 10 instances across the categories. In these instances students claimed that certain things were more or less likely to happen, “Because it is a story” and
certain things do (or do not) happen in stories. Additionally, for responses where they were completely certain that their particular inference would happen, they relied on data of some form to make that judgment, representing the most significant use of data in this way. For example:

I: So we have seen a lot of people in Oatdale. If we were to go to Oatdale, what kind of animal do you think that we would see the most?
S3: I think 'cause there are two dogs that there are actually a lot of dogs.

In this case S3 did not express any uncertainty with their inference and also explicitly referred to the two dogs in the picture when reasoning. Thus, this is an example of using data to express certainty.

By fourth grade, the use of story was still present, although not as prevalent. In fact, there were only 6 instances where fourth-grade students utilized the story context to make judgments about uncertainty. Overall, fourth graders were more in-tune with the data when they were thinking numerically about uncertainty with all 5 instances of supporting a numerical chances expression of uncertainty relying on data.

**Across the Grades.** Another important result from Table 4.5 across all of the grades is the number of times that students made their decisions about uncertainty based on the fact that they were reasoning with a story setting. This occurred a total of 22 times across the grades and was present within all three grade levels. The story setting seemed to lead students to infer that certain things would or would not happen because of what did or did not happen in the story. Although all grades exhibited this behavior, it was most prevalent in second graders’ reasoning. While still present with older students and
with other stories, a majority of this type of reasoning also occurred with the same story, *Sylvester and the Magic Pebble*, which is a fable.

**Summary of Students’ IIR**

In terms of making and evaluating inferential claims the data showed that Kindergarteners, after making original inferences, were most likely to abandon or counter another’s previously stated inference. This was much more frequent than the instances of agreement with another’s inference. Their inference-making could be characterized by the desire to insert their opinion coupled with the readiness to quickly abandon their previously held belief for a new one without necessarily having a prepared rationale for doing so. In short, Kindergarteners seemed to be thinking out loud in an instinctual and reactionary fashion. As a consequence they were overly aware of any range of possibilities, even to the extent of inventing scenarios where extreme inferential claims made my researcher or members of the group could be possible. However, once they settled on their final thoughts, they were often completely certain that their inference would actually happen. This creates an interesting dichotomy where on the one hand they recognized numerous amounts of possibilities while still being completely certain that they knew what would happen. This meant there seemed to be a disconnect between what could happen and what they expected would happen. Their thinking about what could happen did not have a significant impact on what they thought would happen.

Second graders could be described as original inference-makers who had their own thoughts about the inferences they were asked to make. This differed from simply providing counter-inferences, because it involves acknowledging the likelihood of other’s
inferences using probabilistic language without striking down those ideas. They would often acknowledge the possibilities of other’s inferences and then offer their own. While second graders acknowledged the possibility of other’s inferences, they were still generally very certain about the likelihood of their own actually happening. Therefore, they are beginning to acknowledge the range of possible inferences that are reasonable, but still end up believing strongly in their own. This is a bit of a softening from a Kindergartener’s point of view. The important difference here is that second graders are able to acknowledge that there is some degree of likelihood that others’ inferences could possibly happen. They essentially have a more advanced understanding of data than Kindergartners.

Fourth-grade students were different from both kindergartners and second graders. Fourth grade students’ IIR can be summarized as involving reasonable rationales for their inferences that were often built on explicit pieces of data. Older students in general demonstrated less countering and more agreeing probably because they made more reasonable inferences in the first place and supported them with more reasonable rationales. However, while they accepted ideas more often, they still acknowledged some degree of uncertainty. This is where their use of probabilistic language came into play. A vast majority of the instances of addressing uncertainty involved expressions of probabilistic language. They did seem to struggle to provide rationales at times due to an underdeveloped statistical vocabulary, however. As a result they mainly used words and phrases like, maybe, possibly, it could happen, probably not, could be, and improbable. Once one fourth-grade student introduced language about percentages and numerical
chances into the discussion, this language was picked up and utilized by others, further illustrating the need. This suggests that fourth grade students are ready, willing and able to put specific numerical language to the sea of probabilistic language terms they use.

**Research Question #2**

The second research question for this study was, “In what ways, and to what extent, does the Storytelling-Questioning approach provide students with opportunities to engage in IIR?” In answering this question, the analysis of Storytelling-Questioning and its benefits for engaging in IIR was done by examining three components, the stories utilized, the questions asked, and the questions that teachers ask in general during storytelling. This section will begin with the last of these components in order to establish a contrast between the typical questions asked by teachers during storytelling and the questioning that occurred during the Storytelling-Questioning episodes conducted by the researcher.

**Characterizing the Questions Teachers asked During Storytelling**

One teacher from each grade level, Kindergarten, second grade, and fourth grade, was observed reading a story to her class. The intent of collecting this type of data was to identify the types of questions teachers typically pose during storytelling and to see whether or not they naturally pose questions that engage students in IIR. This serves as a point of contrast for the Storytelling-Questioning approach used in this study. Each teacher read one of the stories from this study in a way that represented the typical use of stories in their classroom. To help ensure that the storytelling mirrored typical classroom practices, the teachers were each allowed to choose the story they felt was best suited to
their purposes. The Kindergarten teacher chose June 29, 1999 and both the second and fourth grade teachers selected Miss Malarkey Leaves No Reader Behind. It is worth noting again that since only one fourth-grade teacher participated in the study, she had to select a story intended for younger children so that the student participants from her class would remain unexposed to the stories being used by the researcher. Results from this section should be understood with this in mind.

The teacher questions were first identified as either addressing IIR or not addressing IIR and then those questions that did address IIR were further categorized using the three IIR components. Questions that asked students to make or evaluate inferential claims (whether specifically about the story or inspired by it) were included in the Make/Evaluate Claim Beyond Data category. Questions that specifically asked students to describe what data they were relying on to make or evaluate their inferences were included in the Referencing Data category. Questions that asked students about the certainty of their inferential claims were included in the Attending to Uncertainty category. Table 4.6 illustrates the distribution of the types of questions that the three teachers asked.

Table 4.6

<table>
<thead>
<tr>
<th>Types of Questions Teachers Asked during Storytelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-IIR Teacher Question</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>2nd</td>
</tr>
</tbody>
</table>
The first main finding was that the majority of teacher questions did not directly address IIR. In fact, roughly 80% of the teacher questions were not focused on elements of IIR at all. The non-IIR questions seemed to center around making certain that students were following the plot of the story or that they comprehended the textual elements of the story. These non-IIR questions also included instances where teachers wanted to make sure that students understood the pictures that accompanied the story and instances focused on the vocabulary of the story. Across this non-IIR question category, teachers asked questions like, “Who heard a word they didn’t know?”, “If it is May, how close are they to the end of the year?”, and “What are they doing in this picture?” The most common of these types of questions were questions about the plot of the story. For example, it was common to ask, “What just happened?” or “What did we just learn?” after reading a particular page. This type of question comprised 52 instances out of the 80 total non-IIR questions.

The second most frequent type of non-IIR question was those related to understanding the visuals of the story. For example, teachers asked, “Is there something in the picture that makes you feel that he is sad?” and “What can you see in the picture to show that they are not on Earth? These occurred in 15 out of the 80 non-IIR instances. A

<table>
<thead>
<tr>
<th>4&lt;sup&gt;th&lt;/sup&gt;</th>
<th>28 (80%)</th>
<th>6 (17%)</th>
<th>0 (0%)</th>
<th>1 (3%)</th>
<th>35 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>80 (82%)</td>
<td>14 (14%)</td>
<td>2 (2%)</td>
<td>2 (2%)</td>
<td>98 (100%)</td>
</tr>
</tbody>
</table>
specific instance involved the story *June 29, 1999* where a teacher asked, “How are these people trying to hold the peppers to the ground?” In the visuals there are red peppers that are floating down from space and they are being tethered and held by people. It is interesting to note that this visual element of the story happened to be a basis for one of the IIR focused questions from the Storytelling-Questioning protocol. The remaining non-IIR teacher questions were mostly questions looking for additional input from students, “What do you think about what he said?” or “What do you think about that?” were examples. It is important to note that these types of questions are sufficiently open-ended so that students could venture into an IIR direction with their responses. In fact, this did occur on two occasions. Although student responses were not a focus of this component of the study, it was documented in the field notes that these impromptu inferences were provided by students in response to the question, “What are you thinking about now?” While this question was not intended to explicitly elicit IIR, it left space for students to think in that manner.

At times with the teachers observed, IIR was directly elicited. This is the second main finding coming out of Table 4.6. In general, they provided some opportunity for students to make inferences, but rarely followed up by asking them to communicate what data supported their claims. In addition, teachers rarely asked students how certain they were about their inferences. Table 4.7 provides the 14 questions that were included in the “Make or Evaluate Claims” category.
### Table 4.7

**Characterizing Teachers’ Make/Evaluate a Claim Questions**

<table>
<thead>
<tr>
<th>Question</th>
<th>About Plot</th>
<th>Numerical/Categorical Data</th>
<th>Followed by Data (D) or Uncertainty (U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why would she be sending them to the sky?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Where do you think those turnips are coming from? (twice at two different points)</td>
<td>Y</td>
<td>Cat</td>
<td>D (Twice)</td>
</tr>
<tr>
<td>How is he going to win a blue ribbon?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Who thinks that they know what is going on?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Do you think that he is going to find any books interesting?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Think about this, where do you think that circles would go if you read 1000 books instead of 300?</td>
<td>N</td>
<td>Num</td>
<td>None</td>
</tr>
<tr>
<td>What do the rest of you think?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Who thinks they know what the problem is?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Do you think that she will find a book for him, its already March?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>We are already in May, is she going to find him one?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Is the school going to make their goal of 1,000?</td>
<td>Y</td>
<td>Num</td>
<td>None</td>
</tr>
<tr>
<td>Do you think that this is the one?</td>
<td>Y</td>
<td>Cat</td>
<td>None</td>
</tr>
<tr>
<td>Do you think that the character is hooked on books or do you think that it was a glitch?</td>
<td>Y</td>
<td>Cat</td>
<td>U</td>
</tr>
</tbody>
</table>

In terms of the questions that teachers asked that required students to make or evaluate an inferential claim, three qualities seem apparent. These were their focus on the story’s plot, the types of data referred to in the story, and how inference-making was followed up with data or uncertainty. One can see that there were only three instances
where a teacher followed a question requiring a student to make an inferential claim with a follow up question about data or uncertainty. In the instance above where a follow-up question that related to data was asked, the teacher asked “Why would they be coming from the sky?” when a student responded to the original question with “From the sky.” This question directly asked the student to expand on the claim by asking for support for the claim. The other instance of asking for supporting data was with the same teacher and with the same question, just directed at a different student who also thought that turnips would come from the sky. In this case the teacher asked the same question, “Why would they be coming from the sky?” In the one instance where a follow-up question asked the students to attend to uncertainty a teacher asked, “Do we really know?” following the questions, “How many of you think that main character was hooked on books?” and “How many of you think that it was a glitch and we will not go back to reading books?”

It is also important to note that in all cases but one, when teachers asked students to make inferences, they did so based on the plot of the story by asking “What do you think will happen next?” And the data available for the students to rely upon when making their inferences in these instances was fundamentally categorical (using a sequence of occurrences) rather than numerical. In the one instance where a question was posed that involved numerical data, the book seemed to lend itself to this reference. In Miss Malarkey Leaves No Reader Behind there is a reading competition where the school is attempting to read 1,000 books and one wonders throughout the book if the students will reach their goal.
Overall, while there was some opportunity for students to engage in IIR, this engagement was very limited in these episodes. A majority (approximately 80%) of teacher questions were not related to the components of IIR. Additionally, the inferences that were elicited were focused more on elements of the story’s plot. Even when students made inferences based on the plot of the story, they relied on categorical data. And after requesting these inferences teachers rarely followed-up with questions about supporting data or uncertainty. Finally, and most importantly for the purposes of this study, there were no instances where students were questioned in order to engage them in all three components of IIR around a single issue as in the overall pattern of questioning utilized in Storytelling-Questioning. This suggests, as anticipated, that the questioning patterns of the Storytelling-Questioning protocol are not ones that occur naturally in these classrooms, with these teachers, and these stories.

**Analysis of Questioning from Storytelling-Questioning**

This section contains the analysis of the Storytelling-Questioning approach beginning with an analysis of the questions asked by the researcher. This analysis was built directly out of the results from research question #1. Since the findings from the data analyzed for research question #1 showed that students of this age are capable of engaging in IIR through Storytelling-Questioning, it was important to next determine which questions elicited that engagement and which did not.

**Questions Resulting in Strong Engagement in IIR**

The purpose of most of the questions asked during the Storytelling-Questioning episodes was to elicit students’ abilities to engage in the three components of IIR. As
such, it was important to understand if particular types of questions affected whether
students engaged in these three aspects of IIR or not. For this reason, it was important to
connect the questions asked to the kinds of responses that students gave. First, questions
were identified that resulted in strong engagement with IIR. Strong engagement is
defined as segments where at least one of the three students in a group engaged in all
three components of IIR in response to a single question or a series of related questions
and the other two students engaged with at least two out of the three components of IIR.
Table 4.8 shows all of the sets of questions that resulted in strong engagement with IIR.
Table 4.8

*Questions Eliciting Strong IIR Engagement*

<table>
<thead>
<tr>
<th>Group(s)</th>
<th>Story</th>
<th>Sets of Questions</th>
</tr>
</thead>
</table>
| K – Group 1 | June 29, 1999 | • I counted it takes 16 people to hold this pepper down. How many people do you think that it will take to hold this other pepper down?
• Well, you said that you thought 16 earlier. Why do you think that?
• You are giving a lot of options—why do you not know for sure?
• What if I said that 2 people could do it? |
| K – Group 2 | | |
| 2 – Group 2 | Sylvester and the Magic Pebble | • So I looked at these pebbles that he was picking up and I counted 10 gray ones and 3 brown ones and 2 orange ones and 2 yellow ones. So if he were to go out and find 5 more pebbles from the same place, what colors do you think they would be? |
| 4 – Group 1 | | |
| 2 – Group 2 | Sylvester and the Magic Pebble | • Now Sylvester has searched through a lot of pebbles and now he has found one magic pebble. So if he were to look through...let’s say that he looked through 30 pebbles before he found this one. If he looked through 200 more pebbles how many magic pebbles do you think that he would find?
• Yeah, why one more?
• What do you think?
• Is that what you were thinking?
• Could it be one or two? |
Table 4.8 – Continued

4 – Group 2  \textit{Nothing Ever Happens on 90\textsuperscript{th} Street}

- What if we said that on Monday Mr. Chang sold 5 fish and on Tuesday 2 fish and on Wednesday no fish, and on Thursday 3 fish. How many do you think that he would sell on Friday?
- Okay, 5 and 4. Why do you say 4 then?
- Why do you think 3 [talking to S3] and 5 [talking to S1]?
- So what do you think that the numbers would look like next week for his selling?
- What do you think about what they said?
- Yeah, do you know for sure?
- Do you know what probably would happen?

4 – Group 1  \textit{Nothing Ever Happens on 90\textsuperscript{th} Street}

- I counted we have met 7 females and 3 males so far on 90\textsuperscript{th} Street. So if we were to run into 10 more people, what genders do you think that we would see?
- How many of the ten would be women?
- Yeah, why do you think that?
- What if I said that I think that all 10 will be boys?

Examining Table 4.8 reveals three main findings about the questions that were effective in eliciting IIR. The first common thread through each of these sets of questions is that they are in some sense self-contained, meaning that all of the information you need to make a reasonable inference is located within the question or it’s prompt. The information necessary is easily accessible as there is no need to recall past information, collect data off of a visual, or re-read parts of the text.

The second and most straightforward issue is confirmation of the common phrase, “ask and ye shall receive.” In each of the sets of questions above there was at least one question targeted at each of the three IIR components. From the first example, “How many people do you think…?” asks for an inference, “Why do you think that?” asks the students to reflect on the data that generated that inference, and “…why do you not know for sure?” asks for students to attend to the uncertainty inherent in their statistical reasoning. However this alone does not seem to be sufficient. In the next section, similar
examples are provided of sets of questions that attend to each component of IIR, yet weak engagement with IIR resulted.

The final important trend coming out of Table 4.8 is that all of the groups of students in this study except for one (2nd grade – Group 1) had at least one instance of strong engagement with IIR. This means that 5 out of the 6 groups of students experienced at least one moment of strong engagement, suggesting the effectiveness of the questioning across all grade levels.

**Questions Resulting in Weak Engagement in IIR**

There were cases where particular students were not able to engage in the three parts of IIR in response to the questions asked. Weak engagement with IIR was defined as instances where all three students either said they didn’t know or provided irrelevant responses when asked to attend to at least one of the three IIR aspects. There were only four sets of questions that fit into this category. The responses to these questions accounted for a significant portion of the irrelevant or, “I don’t know” responses from this study.

Table 4.9

**Questions Eliciting Weak IIR Engagement**

<table>
<thead>
<tr>
<th>Group(s)</th>
<th>Story</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>K – Group 1</td>
<td>June 29, 1999</td>
<td>● These are bigger than houses. Let’s say that this one is bigger than 4 houses and this one is bigger than 3 houses and this one is bigger than 2 houses…. If other turnips fell from the sky, how big do you think that they would be?</td>
</tr>
<tr>
<td>K – Group 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.9 – Continued

<table>
<thead>
<tr>
<th>K – Group 1</th>
<th>Miss Malarkey Leaves No Reader Behind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• That is really interesting. What do you guys think about that? He thinks that this guy [main character] has 15 ribbons on the wall because he has read 15, some in one week and some in another week. What do you guys think?</td>
</tr>
<tr>
<td></td>
<td>• How many ribbons do you think that he has one the wall?</td>
</tr>
<tr>
<td></td>
<td>• Why do you think that, why do you think 20, 25, 50, or 30?</td>
</tr>
<tr>
<td></td>
<td>• Could it be just one?</td>
</tr>
<tr>
<td></td>
<td>• Yeah, is that possible? Could it be none?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 – Group 2</th>
<th>Sylvester and the Magic Pebble</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Well there are a lot of dogs. So if 3 more dogs came to look from the town, what do you think that those dogs would look like?</td>
</tr>
<tr>
<td></td>
<td>• What if I said that the three dogs that came would be brown because most of the dogs here are brown?</td>
</tr>
<tr>
<td></td>
<td>• What do you think about that?</td>
</tr>
<tr>
<td></td>
<td>• You don’t know? Why don’t you know?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 – Group 1</th>
<th>Miss Malarkey Leaves No Reader Behind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• So it is June, how many books do you think that he will read in the next month?</td>
</tr>
<tr>
<td></td>
<td>• Zero? One? Why do you think that?</td>
</tr>
<tr>
<td></td>
<td>• So why do you think that he will read one or two maybe?</td>
</tr>
<tr>
<td></td>
<td>• What if I said that I think that she will find him a book that he likes and that he will read one?</td>
</tr>
<tr>
<td></td>
<td>• What do you think?</td>
</tr>
</tbody>
</table>

While the questions that elicited strong engagement from Table 4.9 had distinct commonalities amongst the sets, the questions that elicited weak engagement in IIR seemed to be distinctive from one another in important ways. Important differences seemed particular to the grade, story, context, or question. As such, each of these sets was examined as a separate case.

Examining each of the grades individually regarding Table 4.9 revealed one issue with the set of questions asked for each of these unique cases. For the first set of questions from June 29, 1999, an artificial comparison was introduced, a comparison to the sizes of houses. This comparison is not a part of the text or the visuals of the story. As such, students did not have access to a visual depiction of the question. Additionally, this meant that the data from the question had to be recalled from memory or stated again.
since the necessary data was not a part of the text or visuals. In addition, this set of questions also did not contain a question directly focused on issues of uncertainty.

The second set of questions, which comes from Miss Malarkey Leaves No Reader Behind, is an example of necessary data being excluded from the question or prompt. The text of the story provides the amounts of ribbons on the wall for three other students and the visuals of the story provide the current number of ribbons on the wall (should one desire to count them). Without these two access points to the data students struggled to make inferences about the situation.

The third set of questions from the table above came from Sylvester and the Magic Pebble. The visuals from the story include a page full of dogs of different kinds and colors and spots. It was difficult for students to discern a pattern amongst the dogs on that page and it was difficult for students to count the number of dogs. These factors hindered access to all of the data and consequently students were not able to adequately express their rationales for the inferences that they made. Below is an excerpt from the exchange.

   I: What if I said that the three dogs that came would be brown because most of the dogs here are brown?
   I: Hmm What do you think about that?
   S3: I don’t know.
   I: You don’t know? Why don’t you know?
   …
   S3: [Shrugs]
   S1: I just think that it would be brown and black spots because there are not that many.
S1 doesn’t have access to the data necessary to evaluate the likelihood of the inference offered apart from just what they are able to observe, which in this case involved how few brown and black spotted dogs there were.

Finally, the last case of weak engagement with IIR comes from questions centered on the plot of Miss Malarkey Leaves No Reader Behind. In this story the main character has spent month after month after month not liking books. The set of questions on this book that was classified as weak were closely tied to the plot and asked how many books he would like in the next month. The issue with this question seemed to be that the “answer” was too obvious, and as a result, led to a tangential discussion away from the kinds of books the main character would like and towards the kinds of books the students like personally. This caused several non-inferential moments while obscuring the focus of the questions. In this case, the context of the question affected students’ engagement with IIR. This concept will be explored in more detail in the section on stories.

Across of the sets of questions that elicited weak engagement with IIR, there was one additional relevant pattern. While each of the Kindergarten and second grade groups experienced weak engagement with IIR on at least one occasion, this was not the case for the fourth grade groups. Neither of the fourth grade groups experienced a moment of weak engagement with IIR. While the fourth grade groups did not read June 29, 1999 or Miss Malarkey Leaves No Reader Behind, both fourth grade groups did read Sylvester and the Magic Pebble. The difference between these situations was how the issue of uncertainty was addressed. With the fourth grade group the question intending to get students to confront uncertainty was, “Are you certain that there will be one out of those
three dogs that will be spotted?” (Note that the students’ claims involved spotted-ness rather than color like the second grade group). In the case with second graders shown above in Table 4.9, the question was, “What if I said that the three dogs that came would be brown because most of the dogs here are brown? What do you think of that? You don’t know? Why don’t you know?” In the first case, the question asked of the fourth graders was direct and specific. It directly asked students about their certainty with a specific inference. This contrasts with the question asked of the second graders, “Why don’t you know?”, which did not seem as clear. A more direct question, such as “What makes you unsure about whether the three dogs will be brown?”, would have likely resulted in a more focused response.

**Set-up Questions from Storytelling-Questioning**

The final aspect of the questioning that was analyzed is the potential benefits of the non-inferential warm-up questions in the Storytelling-Questioning approach. In spite of the fact that these types of questions were not intended to elicit IIR, questions like, “What are you thinking about now?” were still included in the Storytelling-Questioning protocols for a couple of purposes. First, these types of questions served to break the ice and get the discussion started so that students would feel more comfortable sharing and engaging in discussion. Secondly, these types of questions provided an opportunity to establish, in a limited way, the norms for the storytelling-questioning time, hopefully improving the power of the IIR-related questions that followed. In almost all cases the “What are you thinking about right now?” question did accomplish this. However, as seen in the example below, sometimes this question resulted in much more.
I: What are you thinking about right now?
S2: Nothing.
I: What were you thinking?
S3: Oh, nothing.
I: Oh, nothing.
S1: Wait, I am actually thinking of something. I think that the guy has 15 ribbons and I know why, because he only read a few and he might have read some on one week and some on another week so he got to 15 in two weeks.

In this example, S1 offered an impromptu inference (that the guy has 15 ribbons on the wall) and gave a rationale supporting it. This was the only case where a student engaged in more than one aspect of IIR without explicit prompting to do so. As such, it was a very rare occurrence, which leads to examining its potential cause in more detail.

The text of the story may have helped facilitate this impromptu inference/support by explicitly referring to numerical data within the story. The text reads,

“Every time we finish a book, Miss Malarkey puts a blue ribbon on the wall with our name and the book title. She sure has put up a lot of ribbons. Suzy Curtsmirin has 25 ribbons on the wall. Charles Dewey has fifteen. And Brenda Johns finished 5 books this week! I mean, FIVE BOOKS in ONE WEEK! How can she do that? Doesn't she eat?”

This proved fruitful for engaging in IIR without explicit prompting. So much so that this impromptu inference and support was given by a Kindergartener at the start of the first storytelling-questioning episode after only being asked prior to this, “What do you think that this book is about?” and “What makes you say that?” This instance illustrates that the affordances of Storytelling-Questioning extend beyond the questions asked to include the story itself.
Analysis of the Stories used in Storytelling-Questioning

Just as the questioning piece of storytelling-questioning was shown to impact how students of different grades were able to interact with IIR, particular features of the stories likewise seemed to either assist or hinder the overall goal of engagement. The first issue that will be addressed is the qualitative, big picture differences between the stories. The next part of the analysis will involve the data used to investigate research question #1. The next three tables are duplicates of the tables used to examine inference-making, support statements, and uncertainty from research question #1 except that they are now delineated by story rather than by grade level.

Distinctive Features of the Stories

Table 4.10 organizes some of the key differences between the four stories. Many of these qualities were addressed in the description of the individual stories and the story selection process detailed in Chapter 4. This table serves as a summary table of distinctive features so that the later components of this analytical section can be understood in light of these features. The interpretive connection between Table 4.10 and the tables which follow will be the subject of discussion within Chapter 5.

Table 4.10

<table>
<thead>
<tr>
<th>Story</th>
<th>Patterned Text vs. Non-Routine Text</th>
<th>Practical vs. Magical</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 29, 1999</td>
<td>Patterned: Much of the story follows the pattern, “[Vegetable] lands on [City Name]”</td>
<td>Magical: Gigantic vegetables float down from space as a result of an alien accident.</td>
</tr>
<tr>
<td>Miss Malarkey Leaves No Reader Behind</td>
<td>Patterned: Miss Malarkey brings a book, the main character doesn’t like it he’d rather play video games. This repeats for much of the book.</td>
<td>Practical: This story takes place in a classroom and is about a student not liking to read. All elements of this story could occur in real life.</td>
</tr>
</tbody>
</table>
Table 4.10 – Continued

<table>
<thead>
<tr>
<th>Story Title</th>
<th>Non-Routine:</th>
<th>Magical:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sylvester and the Magic Pebble</strong></td>
<td>There are not significant repetitions within the narrative of the story.</td>
<td>Sylvester (a talking donkey) finds a pebble that grants wishes and lives in a town with other anthropomorphized animals.</td>
</tr>
<tr>
<td><strong>Nothing Ever Happens on 90th Street</strong></td>
<td>There are not significant repetitions within the narrative of the story.</td>
<td>Practical: This story is about the events that happen when the main character walks down 90th street and how to write about them in a story.</td>
</tr>
</tbody>
</table>

**Inference Making Organized by Story**

Table 4.11 below shows the different types of inferential or non-inferential claims students made by story. It is important to note that the numbers of groups utilizing each story was not equal, so percentages are included to assist with comparisons across stories.

Table 4.11

<table>
<thead>
<tr>
<th>Making or Evaluating Inferences Broken Down by Story</th>
<th>Non-Inferential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Response / I don’t know</td>
</tr>
<tr>
<td><strong>Making Inferences</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Original Inference</strong></td>
<td>Agreement with Another’s Inference</td>
</tr>
<tr>
<td><strong>June 29, 1999</strong></td>
<td>36 (49%)</td>
</tr>
<tr>
<td><strong>3 Groups</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Miss Malarkey</strong></td>
<td>40 (48%)</td>
</tr>
<tr>
<td><strong>4 Groups</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sylvester &amp; M.P.</strong></td>
<td>26 (36%)</td>
</tr>
<tr>
<td><strong>3 Groups</strong></td>
<td></td>
</tr>
<tr>
<td><strong>90th Street</strong></td>
<td>18 (42%)</td>
</tr>
<tr>
<td><strong>2 Groups</strong></td>
<td></td>
</tr>
</tbody>
</table>

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The most distinctive feature of the data regarding June 29, 1999 is the percentage of non-inferential responses given under this story. 11% of the responses in June 29, 1999 were non-inferential compared to 5%, 4%, and 1% for the other three stories. Below is an example of two instances of non-inference from June 29, 1999.

I: What if I said that I think that we are going to see some apples? What do you think about that?
S2: I’d like to eat that up.
I: Yeah. You like apples?
S3: I would throw them at people.

The distinctive feature of the stories Miss Malarkey Leaves No Reader Behind and Nothing Ever Happens on 90th Street is that the data around these two stories is comparable. Each of these stories had more instances of abandoning or countering inferences when compared to the ratio of instances of agreement. For Miss Malarkey the comparison is 29% to 17% while for 90th Street the comparison is between 30% and 23%. In regards to the story Sylvester and the Magic Pebble relatively fewer instances of original inferences were elicited, while a greater proportion of agreements were present.

Supporting Inferences Organized by Story

Table 4.12 examines the kinds of data that students relied on when making inferences in light of the four particular stories. Again while the questions asked and stories they are born out of can conflate each other, there is important information about the impact of the stories located within this table particularly when it comes to the issue of context.
Table 4.12

Supporting Inferences Broken Down by Story

<table>
<thead>
<tr>
<th>Story</th>
<th>Explicit Textual</th>
<th>Implied Textual</th>
<th>Explicit Visual</th>
<th>Implied Visual</th>
<th>Non-Personal Context</th>
<th>Personal Context</th>
<th>No Evidence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 29, 1999</td>
<td>5 (11%)</td>
<td>2 (4%)</td>
<td>14 (29%)</td>
<td>3 (6%)</td>
<td>12 (25%)</td>
<td>2 (4%)</td>
<td>10 (21%)</td>
<td>48</td>
</tr>
<tr>
<td>3 Groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miss Malarkey</td>
<td>18 (21%)</td>
<td>2 (3%)</td>
<td>12 (14%)</td>
<td>7 (8%)</td>
<td>13 (16%)</td>
<td>14 (17%)</td>
<td>18 (21%)</td>
<td>84</td>
</tr>
<tr>
<td>4 Groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sylvester &amp; M.P.</td>
<td>12 (23%)</td>
<td>2 (4%)</td>
<td>16 (30%)</td>
<td>2 (4%)</td>
<td>13 (25%)</td>
<td>5 (10%)</td>
<td>2 (4%)</td>
<td>52</td>
</tr>
<tr>
<td>3 Groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90th Street</td>
<td>2 (7%)</td>
<td>3 (11%)</td>
<td>10 (36%)</td>
<td>2 (7%)</td>
<td>6 (21%)</td>
<td>2 (7%)</td>
<td>3 (11%)</td>
<td>28</td>
</tr>
<tr>
<td>2 Groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first aspect that stands out is that students utilized explicit visuals from the story Miss Malarkey only 14% of the time. This is a low percentage when compared with the 29%, 30% and 36% values from the other three stories. In addition, if you contrast the use of both explicit and implicit visuals together, the percentages are 22% for Miss Malarkey and 35%, 34%, and 43% for the other stories. This is quite surprising considering that two of the four major questions from the storytelling-questioning protocol focus on important visuals of the story. One question centers on the number of ribbons on a wall and the other centers on descriptive aspects of students in a cafeteria.

The second and possibly most important finding from this table is the prominent role of context. If the two context-related columns are taken together, the supporting statements for 90th Street, June 29th, Miss Malarkey, and Sylvester were built on context
28%, 29%, 33%, and 35% of the time respectively. This represents approximately one-third of the rationales within each story. In addition, a greater percent of instances of contextual use were explicitly personal for the story Miss Malarkey. One example of this comes from a Kindergartener who said, “Because I would do that, she probably got 4 books and then would read them and then would get more.” Her rationale was based on what she would do in the situation, based on her own personal experiences with the context.

**Attending to Uncertainty Organized by Story**

Table 4.13 is the third and final table connecting the IIR components to the stories utilized. The connection presented here is between student rationales for their statements attending to uncertainty and the individual stories. The students’ rationales about uncertainty are categorized by certainty, probabilistic language, numerical chances, and complete uncertainty with subcategories to distinguish when students were reasoning about uncertainty based on the data or based on the storytelling setting. It is important to reiterate that asking students for rationales about their uncertainty statements was not an explicit component of the Storytelling-Questioning protocols. In spite of the resulting small totals, there were some significant findings.
The primary finding from Table 4.13 has to do with the times when students reasoned based on the fact that they were reading a story. When these instances are grouped together and compared to the total number of rationales provided, 3 out of 15 rationale statements (20%) in 90th Street utilized the storytelling context, 7 out of 27 (26%) for Sylvester, 6 out of 24 (25%) for Miss Malarkey, and 8 out of 17 (47%) for June 29th. Take the following example from Sylvester and the Magic Pebble where one student said when asked about the likelihood of finding magic pebbles:

S3: ‘Um…’cause, ‘cause we knew that he had to get one…
I: For the story?
S3: Yeah.
And in the case of *Miss Malarkey Leaves No Reader Behind*, a student suggested that after searching and searching for a book for the main character, certainly in the end Miss Malarkey would find the main character a book that he likes because “How else could it end?” Since the numbers presented in the table above represent a significant proportion of the total rationale statements, it is clear that students were often reasoning about the likelihood of particular inferences based on the perceived rules for stories and storytelling and not on data and statistical reasoning, no matter the story.

**Summary of Storytelling-Questioning**

The Storytelling-Questioning approach was clearly effective in engaging students at all levels in IIR. This was not due to students’ natural inclinations to discuss these ideas nor to routine classroom engagement with these ideas. These beneficial aspects of the Storytelling-Questioning approach spanned both the stories and the accompanying questions and served to engage students productively. The questions that were asked as a part of the Storytelling-Questioning protocol were largely effective and different from the types of questions typically asked during story time in classrooms. Engaging students in IIR obviously requires asking questions that attend to each component of IIR, but questions also must have a certain amount of specificity. Since children are relatively new to reasoning in this way, more open questions like “Why don’t you know?” generally led to lackluster responses.

In terms of the stories, one goal was to provide a sufficiently complex context within which students could reason about data in a way that might reflect data analysis in the real world. And students did rely on many different types of data, from explicit to
implicit, from textual to visual, and from contextual to irrelevant. From this perspective, the stories did what traditional mathematical word problems could not; that is, elicit a wide variety of data use across a variety of supporting rationales. With that said, there were some differences among the stories that pertained to the familiarity of the context and whether they were practical or magical in nature. Recall that the largest majority of non-inferential statements were found in the story June 29, 1999. While there was certainly interplay between the age of the students, the questions asked, and the story, it seems likely that the magical nature of June 29 led to some of the non-inferential thinking. In addition, there was a large impact on students’ reasoning about uncertainty in this story, along with Sylvester and the Magic Pebble, which also has a magical element to it. There was a sense that “anything goes,” which changed the rules both for making inferences and attending to uncertainty. In these cases, students seemed to think that special rules applied to stories and storytelling when they are magical and often deferred to the storytelling context for their rationales.

Finally, there was the issue of the familiarity of the context of the stories. Miss Malarkey was a story that may have contained a context that was too familiar to children, given the higher rates of the use of personal contexts for support. Given that most children’s books do use and should use familiar contexts specifically to engage children in the stories, this provides a unique challenge both for story selection and for questioning children about IIR when reading these types of stories.
SUMMARY AND CONCLUSIONS

Introduction

“The power of statistics lies in making inferences about the world beyond available data” (Makar, 2014). This power is not just reserved to statisticians; it is accessible on some level to everyone, even very young children. Repeated engagement with Informal Inferential Reasoning over the long term has promise for helping students develop deep statistical understanding (Ben-Zvi et. al., 2007; Makar, Bakker, & Ben-Zvi, 2011). To further this promise into reality, researched-based methods for eliciting and engaging young students in IIR are needed. As such, this study focused on learning about young students’ IIR through Storytelling-Questioning and analyzing Storytelling-Questioning as a method of engagement with these ideas. What follows is a discussion of these ideas based on the analysis described in Chapter 4 and their connection to already established research ideas, as well as reflections on the study as a whole, both limitations and future work.

Findings and Implications Related to IIR

In many respects the Informal Inferential Reasoning of Kindergarten, second, and fourth grade students mirrors biological and mathematical development occurring during these grades. Kindergarteners are focused on themselves and their own inferences, certain that they will come to pass. Second graders acknowledge the possibility of other’s inferences but do not weigh them heavily enough to impact their own thinking. Fourth graders confront the middle of the probability continuum and seek language to express the numerical chances of inferences coming true. In the background of all of this
reasoning is the data that students acknowledge as important and the data that they actually utilize. The students’ data use encompassed many different types of data, including textual, visual, and contextual. It also spanned appropriate and inappropriate uses. Students were challenged to use data productively as they often reasoned by using personal experiences or the storytelling context to ground their reasoning. Building off of these ideas and extending the work of this study is the goal of this chapter. Within this section on the implications of the findings related to IIR, two major ideas will be addressed. First are the implications of the IIR framework as a structure for thinking about young students’ interactions with data. Second are the implications of IIR as a component of statistical reasoning more generally.

The Informal Inferential Reasoning Framework

The Makar and Rubin (2009) framework for describing IIR was useful for characterizing the IIR of young children in that all of the reasoning and rationales provided by Kindergartners, second graders, and fourth graders fell into one of the three categories of IIR. Given that the questions from the Storytelling-Questioning protocol were directly addressing these three areas, it is not surprising that this occurred. However while students provided statements in response to specific IIR-related questions, it was unclear whether students were genuinely engaging in the targeted IIR component or whether they were providing convenient responses without deep thought. For research studies seeking to describe the IIR of young students, this must be accounted for. To that end, further explicating the first IIR component of making or evaluating inferential claims, by describing whether students were providing original inferences, expressing
agreement with other’s inferences, or abandoning/countering other’s inferences, was a necessary and useful extension of the original IIR framework. These finer categories for the first IIR component seemed to give a more complete picture of students’ reasoning.

Of the three categories, making or evaluating “original” inferences is probably the most important extension of the first IIR component, because they almost certainly consist of the student’s own inferential thinking. The other subcategories of agreeing and countering were probably less important modes of engagement with the first component of IIR. For instance, agreement amongst the fourth graders often took the form of agreeing with almost any inference that had a somewhat reasonable rationale accompanying it. This indicated that their IIR was probably not developed enough to distinguish between the likelihood of a set of reasonable inferences. As such, while agreeing with others’ inferences is at times a statistically reasonable response for students to make, it may not be the most reliable way to characterize the ways in which students engage with the first component of IIR.

Regarding the final two IIR components there was one factor that seemed relevant to children’s reasoning in these areas that was not completely addressed by the Makar and Rubin framework. This area was their ability to recognize relevant data. One may argue that the second component of the Makar and Rubin definition of IIR addresses this issue. However, it can be interpreted as only calling attention to whether or not students explicitly use data to support their inference-making, rather than also accounting for what type of data that might be. Their emphasis on the explicit use of data seems to presuppose that students have been able to recognize both if a piece of information is data or not and
if it is relevant or not. However, it was clear from this study that students at this age were challenged to recognize relevant data as the use of irrelevant data accounted for a significant proportion of students’ engagement with IIR. Therefore, it may be the case that in order for the Makar and Rubin characterization of IIR to be used as a research framework for IIR, it is in need of a prerequisite component on “acknowledging relevant and useful data.” This would help establish a foundation for students to then productively engage with the three IIR components identified by Makar and Rubin.

This recommendation to enhance the IIR framework is also supported by the findings from a study about the statistical reasoning of middle school students (Ben-Zvi and Arcavi, 2001). They attempted to move students from a local view of data (considering data values individually) to a global view of data (considering the data as a whole) through Exploratory Data Analysis (EDA). The EDA exercises used by Ben-Zvi and Arcavi (2001) focused on having, “…students engaged in doing, investigating, discussing, and making conclusions” (p.60). Interestingly, similar to the elementary school students in this study, the middle school students in the Ben-Zvi and Arcavi study had an, “…initial focus on irrelevant features of the data or the inability to focus on anything at all…” (p.46). They identified this issue as one of the issues with students’ prior knowledge that was a hindrance to the progress students made under EDA. This provides further confirmation that an expanded IIR research framework to include the issue of recognizing relevant data is important for the complete description of IIR and for the improvement of IIR.
The Ben-Zvi and Arcavi study (2001) also suggests a potential role that productive engagement with IIR can play in the future; that is, in improving students’ statistical reasoning more generally. If identifying and discussing relevant and irrelevant data during discussion about inferences was an adjustment made to the framework underlying the Storytelling-Questioning approach, it is hypothesized that this adjustment would provide fruitful opportunities to confront this issue with appropriate questions and student arguments. If students can learn to identify relevant data, later statistical work can build on this understanding without needing to first address this issue. With the amount of formal statistical education that is focused on in a short time period in middle school, spending the time to effectively get students to sort through the complexities of contextual data in a way that places data relevancy at the forefront of the discussion would be an important contribution to statistics education.

**Findings and Implications Related to Storytelling-Questioning**

The Storytelling-Questioning approach at the heart of this study provided a productive environment for engaging young students with IIR. This section will deal with the implications, affordances, and constraints of the SQ approach. First, issues related to the stories will be discussed. This includes issues like the use of personal contexts and magical story elements. Second, the implications of the questioning will be discussed along with suggestions for tailoring the questioning to particular grade levels. Third, thoughts about the amount of exposure to SQ that might be required to encourage IIR as a habit of mind will be discussed. Finally, the overall structure of the Storytelling-
Questioning episodes will be discussed to address implications for full-classroom implementation.

Garfield and Ben-Zvi (2008) identify that, “…there is little empirical research on the effectiveness of different instructional strategies, sequences of activities, or technological tools in helping students develop correct reasoning about statistical inference.” They bemoan this fact as they also identify the benefits of placing informal discussions of statistical ideas before the formal applications. Their concern is primarily with high school and college aged students and their inability to succeed at formal statistical inference. They suggest the use of two pedagogical methods for helping make a connection between informal statistical inference and formal statistical inference. First, the teacher should model thinking that connects claims to conclusions, checks conditions and assumptions, and asks questions of the data. Second they state that this discussion should take place within the context of making arguments about claims and supporting data (Garfield & Ben-Zvi, 2008).

This study contributes to the field by being a test case for these hypothesized ideas at the elementary school level. While Garfield and Ben-Zvi (2008) were focusing on much older students in their chapter reviewing literature from this area, the ideas they suggest for implementation could be achieved through Storytelling-Questioning. As such, the connection between the IIR of elementary school students and formal statistical learning later on could be achieved by further refining and developing the argumentation around claims, data and uncertainty that was shown to occur during the Storytelling-Questioning episodes.
Part of the motivation for focusing on IIR in elementary school came from the research by Perkins, Farady, & Bushey (1991), who said, “The most striking of these principles is that increased content knowledge is not likely to improve informal reasoning abilities and neither is biological development or life-experience” (p. 3). They go on to say that informal reasoning abilities need to be explicitly taught. The results from this study suggests that this may not be accurate in that there were some clear differences between grades, and in some cases, clear increasing or decreasing trends across the grades. Therefore, it may be the case that biological development does play a part in developing IIR. However, it is not clear as to whether the improvements across grades suggested by the data in this study suggest a biological change in how young students reason informally or whether they describe the effect of instruction in informal reasoning that may have occurred in these classrooms.

The Nature of Stories

There are two important features of the stories that surfaced as being particularly relevant. First, was the issue of context. *Miss Malarkey Leaves No Reader Behind* was a story that may have contained a context that was too familiar to children, since there were higher rates of the use of personal contexts to support statements. Given that this story was set in a school and most of the questions centered around students and reading, students often made decisions based on their own life experiences. And their life experiences were often irrelevant to the story at hand. This does not suggest that stories with familiar contexts should not be used. After all, most children’s books use familiar contexts specifically to engage children in the stories. However, to engage children in IIR
with these types of stories, the reader needs to make a special effort to encourage them to recognize their own personal experiences and see through them.

Another aspect of the stories selected that had an impact was the extent to which it affected students’ reasoning about uncertainty. *June 29th, 1999* and *Sylvester and the Magic Pebble* both had a magical elements to them. This changed the rules both for making inferences and attending to uncertainty in that children often felt that special rules applied and “anything goes” with these stories. Many seemed incapable of ignoring the magical possibilities in order to focus on what the data might say separate from that. This also made them completely uncertain of the likelihood of inferences.

These findings echo those of Eichler and Vogel (2012), who attempted to model the different cognitive levels of upper elementary school students’ understanding of uncertainty. They found such a large variability in student responses that they were unable to categorize them into general cognitive levels. They claimed that this was due to, “…cognitive levels being provoked by a specific task” (Eichler & Vogel, 2012, p.853). Similar findings from this dissertation study with younger children suggests that perhaps in a future iteration, stories and context could be set up as the main variable of focus in order to provide more clarity to this issue.

These findings have implications for the selection of stories for use in Storytelling-Questioning around IIR. The original story selection criteria utilized in this study focused on whether or not specific moments in the story could be identified where the kinds of intended IIR-related questions could be asked. Provided a story had many opportunities for moments, it was viewed positively in terms of story selection. The
discussion above, however, highlights an important shift in thinking about this that occurred over the course of this study. It seems that story selection must also be informed by the affordances and constraints that particular stories provide for engagement with IIR, rather than just in terms of opportunities to ask IIR-targeted questions. For example, magical story elements and routine story plots, in particular, brought to the surface issues worth discussing concerning data and IIR. Also, stories with intensely personal contexts lead to more productive discussions about relevant and irrelevant data. It is safe to say that not every story will work for every purpose. Therefore, in general the stories best suited for adaptation for this purpose include stories that are engaging to students, provide a familiar but perhaps not too personal or magical context, provide numerical data in either the text or the visuals after the story’s context has been established, and the plot of the story should not be overly routine or easily predictable if the IIR questions are going to be closely tied to the plot.

The Nature of Questioning

Often students did not naturally provide support for their statements. It may be that it is not as natural for children to justify their thinking as it is to make inferential statements. In fact one student even said, “Why? It’s just guessing?” when asked to justify her inference. Even though students did not naturally provide rationales for their inferential claims and at least one student was confused about the purpose, this issue seemed to be overcome somewhat through directed questioning. When asked to provide rationales for their thoughts, a large majority of the time they were able to do so. This illustrates the power of the questioning involved in the SQ approach.
The questioning did elicit several moments that were described as strong engagement in IIR. Returning to Wegerif, Mercer, and Dawes (1999), who said that for the eight and nine year old students in their study, engaging in exploratory talk in groups that included constructive disagreements was beneficial for student learning. When considering the moments of discourse and debate from this study, it was clear that the instances where strong engagement in IIR were identified were also instances where student thinking was at the center of the discussion and they were engaged with constructive discussion amongst themselves. This mirrors the types of beneficial classrooms environments described by Wegerif et al., but goes beyond this by purporting that a context (Storytelling-Questioning) can be created where exploratory talk arises naturally. The Storytelling-Questioning approach creates an environment where norms related to exploratory talk and disagreement can be readily established. Stories provide a rich context within which different students can each make reasonable arguments based on data and the contextual complexity of stories also helps to naturally foster disagreements. The focus on data prompts students to provide rationales and attention to uncertainty naturally draws students to focus on the reasoning of others to consider the most likely interpretation. Therefore, by tapping into children’s innate propensity to discuss stories, the Storytelling-Questioning approach provides a method for establishing the kinds of sociocultural learning environments valued by Wegerif, Mercer, and Dawes.

In addition to adding more questions to the protocols that request rationales, there are other adjustments that could be made in the future to strengthen engagement at each grade level. One area of concern is to make sure that questions are as specific and clear as
possible. Rather than asking a question like, “Are you sure about that?” the question “How certain are you that what he/she said will actually happen?” seemed much more effective. This was especially problematic for Kindergartens working with June 29, 1999 and speaks to the negative interplay that can occur between lack of specific questioning and magical stories. It may also be the case that some of the students, particularly the Kindergarteners, had difficulty understanding the language used in the questions. Interpreting whether students had issues with the questions or the content, however, was difficult to identify.

Beyond just eliciting students’ thinking, questions can also be used to help students improve their IIR. For example, second graders might benefit from questions that are more focused on considering the center of a set of data, because a majority of the students’ IIR at this age consists of favoring their own interpretations in spite of other appropriate inferences with accompanying support. As a result, they often ignore inferences that have the most support behind them. While it is still early to formally consider ideas such as the mean and median of a set of data to help determine which inferences are most likely, certainly the mode is accessible here. Second graders interactions around IIR could also be advanced through strategic questioning that focuses on a group of inferences that students have found reasonable and asks them to compare them. To help students decide amongst several inferences presented one could then ask, “Which of these statements has the most data supporting it?” Additionally to help students reason about the likelihood of a particular inference one could ask, “Which of these data values occurs the most.” This works well with categorical data where the mode
is clearly an appropriate measure of center. With numerical data one would have to be
cognizant of the fact that the mode is often not the most representative measure of center.
Still, this is another case where the questions asked provide a fruitful ground for
extending mathematical and statistical thinking. It would be easy to envision a discussion
of mean or median emerging from questions that ask students to reflect on the numerical
data provided to support their inferences.

Another example of adjusting the questioning to help improve the IIR of a
specific group would be asking fourth grade students, “How many times do you think
that this would happen out of 20 times?” This would be a potentially powerful way to
introduce language for which fourth grade students seem to be searching. This also
speaks to the Garfield and Ben-Zvi (2008) call for teachers to model the kind of
reasoning about claims and data they want to encourage.

**Developing Patterns of Language and Thinking in Storytelling-Questioning**

While it was not a main goal of this study, part of considering the effectiveness of
any instructional approach is to determine its potential to instill generative ways of
thinking. In other words, it would be beneficial to know if students develop habits and
norms productive to engaging in IIR as a result of engaging in Storytelling-Questioning.
Ultimately, one would like to see this kind of reasoning occur spontaneously during any
discussions about contextual data. However, this would clearly be a long-term goal after
a multitude of experiences. With that said, it is interesting to note that there were some
beginning patterns of thinking that surfaced during the storytelling-questioning episodes.
One beginning pattern involved a second-grade group. The first story read to this group was *Miss Malarkey Leaves No Reader Behind*. During the discussion of the opening set of questions the following interchange took place:

S3: Where is Ellen’s name?
I: So Ellen was this one who was running by real fast. [shows previous page] She was reading the book about fire.
S3: Which one was it, it was probably him. It was him.
I: Yeah maybe.
S3: Or maybe it was him. But it probably wasn’t him

When S3 had a question about Ellen, rather than just state that she was the girl on the previous page reading, the researcher flipped back to the previous page to find and show the information that was needed. This action was replicated by students on two separate occasions when S3 and another student from the same group (S1) asked that the book be turned to a previous page so that they could recall some information. This was not an action prompted by the researcher, but was used by these students out of need.

The second pattern worth noting involved an evolution of vocabulary. Within one of the fourth-grade groups, the terms “percent chance” and “__ out of __” were introduced by the students. S1 introduced these ideas right away in response to the first question from the first story saying, “It’s like the matter of the percentages that there is. So if there is like 17 chances of picking out a gray pebble, it is 8% or 10% out of 17.”

While this explanation of percentage is a bit unclear, S1 soon brings it up again saying, “Yes, but it is a small percentage and other students try to expand on his idea. S3 says, “It would be rare” and S2 says, “Yeah, like 10%. Like 10% to 5%.”

Then on the next day, during the second story, the following interchange occurred:
I: What if I said that I think that all 10 will be boys?
S1: Well then you are crazy.
S3: Well it should only be like 10%.
I: Why am I crazy?
S1: Cause there is only like one boy.
S2: Are you serious, like 10%.
S3: No, like 10 out of 100.
S2: It might be more like 8%.

In this instance S1, who originated the idea of percentage and odds, was not the first one to use the terms on the second day. Both S3 and S2 brought out percentages in order to make an argument about likelihood on that day.

While the students’ understanding of percentages and numerical chances were clearly still underdeveloped, the fact that there seemed to be a common vocabulary developing in this environment is promising for individuals wishing to orchestrate conversations like these around particular concepts. This seemed to be a special product of the discussion environment around the stories and is one promising implication for this work.

This represents a new way to utilize stories to teach mathematics and contributes to the research on storytelling and mathematics teaching. This study takes what is most unique about a storytelling situation, the rich world it builds, and utilizes that to impact the understanding of a piece of statistical content. This use of stories forces a confrontation with the role of context in data analysis and necessitates a discussion of relevant and irrelevant data. The larger body of current literature on the use of stories in mathematics describes the benefits as increased levels of engagement (van den Heuvel-Panhuizen, van den Boogaard, & Doig, 2009, Zazkis & Liljedahl, 2009), making the
material more memorable (Egan, 2004), and providing a springboard for mathematical discourse (Anderson, Anderson, and Shapiro, 2004). This study showed that stories can have a specific effect on students’ statistical reasoning by the fact that they provide students with an experience with authentic scenarios involving messy data situations. Therefore, this study adds to the findings on the ways in which stories have been found to be useful for teaching children mathematics.

**The Storytelling-Questioning Format**

The format chosen for the Storytelling-Questioning approach used in this study was small groups of three students. This was chosen to build off of the results of Morrow and Smith (1990) who identified small groups of three as an optimal group size over one-on-one and whole class settings regarding comprehending verbal interactions. While this format was effective for this study, it is likely that teachers would use a whole-class setting to implement Storytelling-Questioning in their classrooms. To do so effectively would require adjustments. This leaves many open questions about the overall viability of this approach for classrooms, since it is possible that many of the affordances of the Storytelling-Questioning approach are particular to small groups of students.

Many of the benefits of Storytelling-Questioning come from establishing a rich environment within which students can talk deeply about statistical issues. In a whole class storytelling setting, this environment may or may not be established depending on the time teachers are willing to devote to this work. They could closely model the implementation of the protocol in this study by pausing for 4-5 moments of discourse and debate and allow as many students as possible to verbalize their thinking. While this
method would provide an opportunity to establish norms related to question-asking and answering around IIR, it would be challenging for teachers to unpack what students have reasoned and encourage them to compare and contrast responses with other statements or other data. This takes time and would likely not occur often within a storytelling episode.

A second scenario for the whole-class setting that is probably more likely is that teachers will allow only enough time to choose one or two moment(s) for discourse and debate per story. Since numerous issues related to IIR could arise (i.e., relevant vs. irrelevant data, use of context, considering others’ inferences, developing vocabulary, developing norms) as well as other mathematical or statistical issues (i.e., measures of center, range, categorical vs. numerical data, percentages, and odds), it would be extremely challenging for teachers to determine which issues to pursue. In addition, one important reason for choosing to engage students around IIR through stories was to establish a rich and real-world context where contextual reasoning is an important consideration for students. With just one moment of discourse and debate (especially if that moment occurs towards the start of the story) there might not be enough time to establish the sort of context necessary for students to utilize it to reason.

In either scenario, not every student will answer questions or express their reasoning during each episode. In fact, some students may (if the teachers do not make it a point of emphasis) never verbally engage with the questions the teacher asks preferring to listen and process. However, it may be the case that over the course of the year the power in encouraging students to think in this way will manifest itself over the long term through repetition. Finally, in both scenarios there is an issue with use of the visuals from
the stories. It may not be possible for students to effectively see and then utilize the visuals of the story in a large group setting. Teachers would have to make a special effort to include and point out the visuals when reading the story and more focused questions, such as “Does anyone see a piece of information in this picture that could help us answer this question?” will need to be included in the protocols. Of course the same sort of question could be effectively directed at the textual data as a way of helping all of the students maintain engagement with a text that is not directly in front of them. As all of the approaches to implementation discussed above have affordances and constraints, likely a mixture of both is an appropriate solution for teachers in the classroom, at time focusing on larger norm-related issues and at other times focusing deeply on specific statistical ideas.

Implications for Teacher Learning

While the teachers observed in this study naturally asked inferential type questions from time to time, it was extremely rare for them to require students to base those inferences on data or for them to acknowledge the inherent uncertainty in statistical situations. As such, professional development sessions focusing on the statistical content of IIR seems necessary to help teachers learn what IIR is, why it is important, and how it connects to the formal statistical learning that their students will do in middle school.

Another feature that would be important for professional development would be to help teachers understand how to craft questions around particular story moments. While the kinds of questions asked in the Storytelling-Questioning protocols follow a certain pattern, they need to be adapted to particular stories. It may be necessary to create
specific “trade-books” that are designed to engage students in IIR and contain teacher support materials that provide rationales for decisions made in the creation of the book. This would assist teachers in applying the support in these hypothetical stories to stories of their own choosing. On their own, these “trade-books” with accompanying support could be a practical way of reaching teachers. However, it is unclear as to whether a sufficient amount of content knowledge related to IIR could be effectively communicated in this format.

Ultimately, it will be paramount to help teachers understand statistics as a discipline. Statistics cannot be viewed as a collection of formulas, operations, and graphs, but as an investigative process (as suggested by GAISE). One way to encourage this shift in understanding of statistics is to help teachers learn about the kinds of reasoning children use when working with data. Conducting professional development sessions where teachers analyze and interpret children’s Informal Inferential Reasoning through storytelling could be a bridge used for doing that.

**Limitations of Study**

This study was limited in several respects. The primary limitation was the amount of data collected. Approximately 6 hours of data was collected between the small group interactions and the teacher observations. This amount of data was sufficient to begin to form substantive conclusions pertaining to the research questions and also provided enough information to inform future iterations of Storytelling-Questioning. However, with only two groups of three students per grade and two stories per group, the number of times a specific question was asked was limited. Additionally, the stories were not
utilized with a consistent number of groups, and one story was only utilized by fourth-grade students given one group’s familiarity with one of the stories. This limited cross-story comparison made it difficult to tease apart which factors (students, questions, stories) actually caused the effects observed.

Another way this study was limited was by the little amount of time spent with the students. The Storytelling-Questioning protocol necessitates a certain type of interaction between all members of the group. Students must be willing and able to talk and discuss ideas both with the researcher and with each other. This dynamic is not easy to create in a short time span if students are not already used to interacting in this way. Another issue layered on top of this is the ambiguous nature of statistical reasoning where more than one “correct” answer may be possible with any number of reasonably defended responses. Instilling this mindset, to the degree that it is possible in young students, is certainly not achievable in a limited amount of 20-minute interactions and calls for a more extensive long-term study.

Finally, this study was limited by, or perhaps defined by, the views and understandings of the researcher. As a participant-observer there was a delicate balance between maintaining the children’s interest in what was going on, establishing norms for the interactions, and eliciting their IIR. As such, the Storytelling-Questioning protocol could not always be followed to the letter. At times questions needed to be skipped or adapted or added at the researcher’s discretion. This also meant that not every student was specifically asked for their thoughts every time they made a statement nor was every inference followed with specific inquiries about the data or uncertainty. In addition,
asking for rationales around thinking about uncertainty was not an original component of the Storytelling-Questioning protocol. While they were applied periodically in the course of the discussions, this inconsistency hindered the analysis in this study. However, this does reflect the realities of teaching and researching in a classroom setting, particularly with young children, and provides an important lesson for future iterations of this work.

**Future Work**

This study is only a start to the process of advancing understanding about the many variables at play here. Certainly an expanded study with more participants utilizing more stories would be valuable in that it would have the potential to provide a more detailed, complete, and generalizable picture of IIR at the early grades as well as a deeper understanding of the strengths and weaknesses of the Storytelling-Questioning approach. Such a study could serve to test the implementation of a revised and improved Storytelling-Questioning protocol. This might entail new stories with new story contexts, new types of questions and an added focus on helping children recognize and utilize relevant data. A future study could also allow comparisons among student responses from this current study to student responses from a different researcher, different classrooms, and altered Storytelling-Questioning protocols. This study could benefit from expansion across each of these variables.

It would also be beneficial to conduct a study that focused on improving students’ IIR over the long-term. This current study was largely exploratory with regard to IIR and only attempted to describe the state of existence of IIR as well as any improvement in IIR that might occur given repeated engagement with Storytelling-Questioning by the
researcher. It did not involve studying any other types of thoughtful interventions the researcher might do to encourage the development of students’ IIR. This study only suggested various interventions that could assist in students’ IIR development (i.e., being explicit about the relevant data for a given question). These suggestions were not a consistent part of this study and would be worth unpacking in a further study. Since the appropriateness of students’ responses were not a consideration during the Storytelling-Questioning episodes, there is still much room to examine the best ways to intervene when inappropriate, or less-than-acceptable responses are given. Additionally, future work could and should focus on how to utilize the affordances of engaging students in the manner described in this study for the improvement of students’ reasoning in general or for the improvement of formal statistical abilities.

Finally, another future direction of this work should be focused on what it would take for teachers to implement Storytelling-Questioning in their classrooms on a whole-class scale. Although storytelling is a natural component of current elementary school classrooms, teachers will need assistance with engaging students in IIR while utilizing Storytelling-Questioning. This type of teacher implementation study could take many forms, but would help identify the supports that teachers need to effectively implement the SQ approach as well as the challenges they face in doing so effectively. Whole-class implementation should also be studied for its impact on student reasoning. It would be important to determine how student use of story elements changes in a whole-class environment and whether their IIR will develop when they may not be able to directly verbalize their answer to many of the questions asked during Storytelling-Questioning.
Final Thoughts

The ideas explored in this dissertation study, which built upon the research that has already been conducted, represent only the beginning of understanding how IIR, stories, questions, young children, and data interact. Understanding the interactions between these variables promises to be a step in the right direction towards eventually developing competent consumers of statistical information. Given the amount of data-based arguments and decision-making present in modern society, this seems to be a worthy goal.
REFERENCES


APPENDIX A
Storytelling–Questioning Protocol (Miss Malarkey)

Storytelling – Questioning Protocol for Miss Malarkey Leaves No Reader Behind

General Principles
1. Every Inference must be connected with a support – The Storyteller-Questioner must pursue EACH child’s reasoning with...
   1. Why? / Why do you think that? / What makes you say that?
   2. How sure are you about that? / Do you know that for sure?
2. Ask students to reflect on what others have said.
3. Ask students to reflect on a claim that the researcher presents.
4. Ask students to reflect on what they said in the past.

Coding for IIR Component the Questions Target:
   IIR1: Attending to Uncertainty
   IIR2: Making and Evaluating Claims
   IIR3: Relying Explicitly on Data

STORY:
Begin by asking “What do you think that this book is about?”
(What makes you say that? How sure are you that you are right? What makes you that sure?) in order to start to establish norms for the conversation.

“It's the first week of school, and this year Miss Malarkey said our class would be doing the Everybody Reads in America program. She thinks that reading is about the finest thing a person can do and she promises to find each of us a book we’ll love before the end of the year. Our school is supposed to read 1,000 books by June 12. Principle Wiggins says that if we can read that many books, he will dye his hair purple and sleep on the roof of the school. I'd love to see that, but there's one problem … I hate reading.”

“In October, Miss Malarkey gave me a book of scary stories. I don't like scary stories. I like video games, and so do my friends. Adwin is from Senegal. He doesn't speak English very well yet, but he really likes math. Sam is good at lacrosse. Jamal likes to draw. Me, I like aliens, race cars, funny jokes, chewing gum, hot sauce, and doing cannonballs in the pool.” “Miss Malarkey handed out a list of books that somebody said we should try:” (List of 10 Nifty book for November).

“The school year is going by fast. It's already December. Everybody is reading. Everybody but me and my friends. We walked by Suzy Curtsmirin. Her backpack was so crammed with books, she looked like she was going to fall flat on her back. ‘What’s in the backpack?’ I asked. ‘Rocks?’”

“We saw Larry Stork reading a book on his way home. He walked right into a telephone pole. Ellen Japson ran by really fast. ‘Where’s the fire?’ yelled Sam. ‘In the book I'm reading! It's great!’ yelled Ellen. ‘The world is going crazy.’ said Jamal. We went home to my house and played video games.”

“Every time we finish a book, Miss Malarkey puts a blue ribbon on the wall with our name and the book title. She sure has put up a lot of ribbons. Suzy Curtsmirin has 25 ribbons on the wall. Charles Dewey has fifteen. And Brenda Johns finished 5 books this week! I mean, FIVE BOOKS in ONE WEEK! How can she do that? Doesn't she eat?”

Moment for Discourse and Debate #1:
What are you thinking about right now?

Ellen Japson is another person in Miss Malarkey's class, how many ribbons do you think that she has on the wall?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that Ellen has 100 ribbons on the wall, What do think about that?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

This is Ellen Japson (show her image on the previous page) and her backpack is full of books. Does that change what you think about how many ribbons she has on the wall?

What do you think about what he/she said? (How likely do you think it is that that would happen?)

If we know that there are 100 ribbons total on the wall for the students in Miss Malarkey’s class, how many of them do you think belong to Ellen Japson?

What do you think about what he/she said? (How likely do you think it is that that would happen?)

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about _______, does that change what you think about _________ )

“Miss Malarkey keeps giving me books. She says that she'll find a book for me if it kills her. I don't want her to die, so I told her I'd keep trying. When I tried to read one of them after I played video games, I fell asleep.”

“It is February now, and Miss Malarkey is still trying to find a book I'll love. She gave me a fantasy book, but the names were confusing.”

“In March, Miss Malarkey gave me a book of jokes, but I'd heard them all before.”

“In April, she tried a book of poems...I don't know what she was thinking. Miss Malarkey doesn't give up easily.”

“In May, she gave me a book about crazy mixed-up explorer guys, but I lost interest before they even set sail.”

Moment for Discourse and Debate #2:

How many books do you think that he will read next month in June?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What kind of book do you think that Miss Malarkey will give to him next?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)
If I said that I thought that she would give him a book about pirates next, what do you think about that? Do you think that that will happen?

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about __________ )

“It's June now, and my friends came over to play video games – everyone but Sam. 'Miss Malarkey gave him a book on Friday,' said Adwin. 'Maybe he is reading?' 'No way,' I said. 'He is out playing some sport.' We called Sam's house. His mother said, 'He's busy right now. I'll have him call you when he's done ... He's reading.'”

Do you remember what was happening in this book?
School's goal
Main character hasn't read
His friends are finding books that they like to read

“It's been months since we started the Oh Gee Wiz, Aren't Books Great program. Miss Malarkey keeps giving me books to read, but I just don't get it. Our class has read 275 books. Our school has read 869 books. Adwin, James, and I have read zero. Video games are just so much cooler.”

“One day at lunch, I sat down with Sam, Adwin, and Jamal. Adwin kept looking down at his lap. 'Did you wet your pants or something?' I laughed. 'Not wet!' said Adwin, and he lifted up a book he was hiding under the table. 'Miss Malarkey give me this book. A good book about this math guy. His name is David Blackwell.'

“That's great, Adwin,' I said, 'You enjoy your stupid book, but Jamal and I going to be video game masters.' ‘Actually,’ said Jamal, 'I thought that was a good book when I read it, too, and I don't think I even like math. I like when the guys said, 'I like pictures. Formulas and symbols – I don't especially like them.' He was a pretty cool guy.”

Moment for Discourse and Debate #3:
Look at the nine kids in this lunchroom, some of them are reading, some of them have glasses, some of them are boys and some of them are girls. If another class of 20 students came to lunch, could you tell me how many of the students would be reading books?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

If another class of 20 students came to lunch, could you tell me how many of the students would be wearing glasses?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

If another class of 20 students came to lunch, could you tell me how many of the students would be girls?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)
What if I said that I think that all 20 of them will be girls?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about __________ )

“My jaw hung open. ‘How long have you been reading books, Jamal?’ ‘A while now, I guess. I didn't want to make you feel bad. See Miss Malarkey gave me this book about a painter Van Gogh. You know how I like cool pictures; this book has a lot of them.’

“My friends read now. They still play video games, but not quite as much. Sometimes, when they come over, they bring books and trade them. Sometimes they barely even play the video games. They talk about books.”

“On June 10, our school has a big assembly for the reading program. We're getting close to the goal of reading 1,000 books. The teachers bought a special sleeping bag for Principal Wiggins for when he sleeps on the roof of the school.”

“The school has read 999 books. Our class has read 334.”

“The next day Miss Malarkey asked me to stay after school. I thought maybe she was going to yell at me about all the books I did not finish. I tried to like reading books. I really did. I tried sports books, science books, joke books, fantasy, explorer, and detective books....”

“What was I supposed to do?”

“When I got to Miss Malarkey's room, she had this crazy smile on her face. She said, 'This year I found out a lot about you. I found out you don't like girl stories, dead baseball players, and math tricks. I found out you're not mean, you don't lie, and you love video games. You like cool sneakers, your lucky number is 15, and your favorite uncle is in the army. Your mother's name is Carol and your father's name is Bob. This year I found out even more about you. You, my boy, like aliens, race cars, funny jokes, chewing gum, and hot sauce, and doing cannonballs in your pool.' Then she yelled: 'I got a book for you!'

I went home that day and started to read. It was the greatest book ever made. It had aliens and race cars and funny jokes and chewing gum and hot sauce and cannonballs. It even had a pool.”

Moment for Discourse and Debate #4:

If Miss Malarkey has 50 books on her shelf, how many of them do you think that he will like to read. What makes you say that?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that now that he has found a book that he likes to read, that he will like all of the books on Miss Malarkey's shelf. What do you think about that?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)
NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific
data and ask them if they think about ______, does that change what you think about _________ )

I read right through dinner, and at ten o'clock my mom and dad came up to see if I was feeling all right.
The next day, Mom wrote a note to Miss Malarkey and told me to give it to her.

Turns out I hadn't read the 1,000th book, I read number 1,001. That's okay because I got to read the greatest
book ever. Miss Malarkey gave me a hug and said, 'Congratulations''

When school was over, everyone went outside and looked up to the roof. We all yelled, 'Good night
Principal Wiggins'
APPENDIX B
Storytelling-Questioning Protocol (June 29, 1999)

Storytelling – Questioning Protocol for June 29, 1999

General Principles
1. Every Inference must be connected with a support – The Storyteller-Questioner must pursue EACH child’s reasoning with...
   1. Why? / Why do you think that? / What makes you say that?
   2. How sure are you about that? / Do you know that for sure?
2. Ask students to reflect on what others have said.
3. Ask students to reflect on a claim that the researcher presents.
4. Ask students to reflect on what they said in the past.

Coding for IIR Component the Questions Target:
   IIR1: Attending to Uncertainty
   IIR2: Making and Evaluating Claims
   IIR3: Relying Explicitly on Data

STORY:
Begin by asking “What do you think that this book is about?”
(What makes you say that? How sure are you that you are right? What makes you that sure?) in order to start to establish norms for the conversation.

The place is Ho-Ho-Kus, New Jersey. The year is 1999. On May 11, after months of careful research and planning, Holly Evans launches vegetable seedlings into the sky. (Do you see the types of seeds she planted? What types do you see?)

On May 18, the young scientist reports on her experiment. Holly intends to study the effects of extraterrestrial conditions on vegetable growth and development. She expects the seedlings to stay aloft for several weeks before returning to Earth. Her classmates are speechless.

The date is June 29. Shortly after sunrise, a member of the Billings, Montana, Moose Lodge, hiking through the Rocky Mountains, makes a startling discovery. Robert Bernabe is in a daze when he returns to camp. All he can say for several hours is, “Turnips!”

Moment for Discourse and Debate #1:

Look at how big these turnips are! This turnip seems to be bigger than 3 houses put together. This turnip seems to be bigger than 2 houses put together. What if this turnip is bigger than 3 houses put together? What if this turnip is bigger than 4 houses put together? If another turnip falls from the sky, how many houses put together do you think that it will be bigger than? Tell me why you say that?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that the next turnip that falls from the sky will be smaller than 1 house? Does that change what you think?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)
NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about __________)

All over the country, the skies fill with vegetables.


**Moment for Discourse and Debate #2:**

*Look at the kind of vegetables that we have seen in the sky. What kind of vegetable do you think that we will see next? Tell me why you say that?*

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I turned back to the first page and we looked at the kinds of vegetables that she sent up to the sky. Does that change what kind of vegetable you think we will see next?

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What I said that by the time that this is over, I am sure that we will see apples falling from the sky? It will happen. Tell me what you think about that?

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about __________)

And broccoli lands with a big bounce in Holly Evans’s backyard.

In Ottumwa, Iowa, Tony Kramer emerges from his barn and shouts for joy. “At last, the blue ribbon at the state fair is mine.”

By mid-afternoon, all vegetables float safely to the ground.

Except for the peppers. For some reason, they need a little help.

**Moment for Discourse and Debate #3:**

*It looks like it takes 16 people holding strings to keep this pepper down at the ground. How many people holding string do you think that it will take to hold this other pepper down at the ground? Tell me why you say that?*

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I tell you that these new peppers are all different sizes? Does that change what you think about how many people you need to hold down the peppers?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about _________)

TV news channels broadcast twenty-four-hour coverage of the “airborne vegetal event.” Cauliflower carpets California, spinach blankets Greenwich, and arugula covers Ashtabula. Holly is puzzled. Arugula is not part of her experiment.

Moment for Discourse and Debate #4:

Do you think that these are Holly’s vegetables that are falling from the sky? Tell me why you say that?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I point out that she did not send any Arugula seeds up into the sky? Does that change whether you think these are her vegetables?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about _________)

Vegetables become very big business. Peas from Peoria are shipped down from the Mississippi to Mobile in exchange for eggplant.

Real estate booms in North Carolina. Avocados bolster Vermont’s economy. Potatoland is widely abandoned. The Big Apple is renamed the Big Rutabaga.

Arugula, eggplant, avocado, and now rutabaga. As the list of vegetables that Holly did not plant grows longer, she concludes that the giant specimens are not the result of her experiment. More curious than disappointed, Holly asks herself, “What happened to my vegetables?” “And whose broccoli is in my backyard?”

The place is the ionosphere. On June 29, the Arcturian starcruiser Alula Borealis was touring its sixth planet in four days, and the captain had just pointed out the fjords of Norway off the port side. In the galley an assistant fry cook accidentally jettisoned the entire food supply. As their vegetables drifted toward the small blue planet below, everyone on board had the same thought: Where will supper come from?
APPENDIX C
Storytelling–Questioning Protocol (Sylvester)

Storytelling – Questioning Protocol for Sylvester and the Magic Pebble

General Principles
1. Every Inference must be connected with a support – The Storyteller-Questioner must pursue each child’s reasoning with...
   1. Why? / Why do you think that? / What makes you say that?
   2. How sure are you about that? / Do you know that for sure?
2. Ask students to reflect on what others have said.
3. Ask students to reflect on a claim that the researcher presents.
4. Ask students to reflect on what they said in the past.

Coding for IIR Component the Questions Target:
   IIR1: Attending to Uncertainty
   IIR2: Making and Evaluating Claims
   IIR3: Relying Explicitly on Data

STORY:
Begin by asking “What do you think that this book is about?”
(What makes you say that? How sure are you that you are right? What makes you that sure?) in order to start to establish norms for the conversation.

Sylvester Duncan lived with his mother and father at Acorn Road in Oatdale. One of his hobbies was collecting pebbles of unusual shape and color.

Moment for Discourse and Debate #1:

Look at the pebbles that Sylvester has collected. See them? I counted and there are 10 gray ones, 3 brown ones, 2 orange ones, and 2 yellow ones. If Sylvester goes out and picks up 5 more pebbles from the same place where he got these, what color pebbles do you think that he will get? Tell me why you say that.
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that all 5 of the pebbles will be orange? What do you think about that?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that we cannot know anything about the kinds of pebbles that he will pick so it could be anything? What do you think about that?

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about __________ )

On a rainy Saturday during vacation he found a quite extraordinary one. It was flaming red, shiny, and perfectly round, like a marble. As he was studying this remarkable pebble, he began to shiver, probably from excitement, and the rain felt cold on his back. “I wish it would stop raining,” he said. To his great
surprise the rain stopped. It didn’t stop gradually as rains usually do. It CEASED. The drops vanished on the way down, the clouds disappeared, everything was dry, and the sun was shining as if rain had never existed.

In all his life Sylvester had never had a wish gratified so quickly. It struck him that magic must be at work, and he guessed that the magic must be in the remarkable looking red pebble. (Where indeed it was.) To make a test, he put the pebble on the ground and said, “I wish that it would rain again.” Nothing happened. But when he said the same thing holding the pebble in his hoof, the sky turned black, there was lightning and a clap of thunder, and the rain came shooting down. He wished the sunshine back in the sky, and he wished a wart on this left hind fetlock would disappear, and it did, and he started home, eager to amaze his father and mother with the magic pebble. He could hardly wait to see their faces. Maybe they wouldn’t even believe him at first. “What a lucky day this is!” thought Sylvester. “From now on I can have anything I want. My father and mother can have anything they want. My relatives, my friends, and anybody at all can have everything anybody wants!”

Moment for Discourse and Debate #2:

Now Sylvester has searched through a lot of pebbles and now he has found one magical pebble. Let’s say that he searched through 30 pebbles before he found this magic pebble. If Sylvester were to search through another 200 pebbles, how many magic pebbles do you think that he would find? Tell me why you say that.

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about ________ )

He was the crossing at Strawberry Hill, thinking of some of the many, many things he could wish for, he was startled to see a mean, hungry lion looking right at him from behind some tall grass. He was frightened. If he hadn’t been so frightened, he could have made the lion disappear, or he could have wished himself safe at home with his father and mother. He could have wished the lion would turn into a butterfly or a daisy or a gnat. He could have wished many things, but he panicked and couldn’t think carefully. “I wish I were a rock,” he said, and he became a rock. The lion came bounding over, sniffed the rock a hundred times, walked around and around it, and went away confused, perplexed, puzzled, and bewildered. “I saw that little donkey as clear as day. Maybe I’m going crazy, he muttered.

And there was Sylvester, a rock on Strawberry Hill, with the magic pebble lying right beside him on the ground, and he was unable to pick it up. “Oh, how I wish I were myself again,” he thought, but nothing happened. He had to be touching the pebble to make the magic work, but there was nothing he could do about it. His thoughts began to race like mad. He was scared and worried. Being helpless, he felt hopeless. He imagined, all the possibilities, and eventually he realized that his only chance of becoming himself again was for someone to find the red pebble and to wish that the rock next to it would be a donkey. Someone would surely find the red pebble – it was so bright and shiny – but what on earth would make
them wish that a rock were a donkey? The chance was one in a billion at best. Sylvester fell asleep. What else could he do? Night with many stars.

Meanwhile, back at home, Mr. and Mrs. Duncan paced the floor, frantic with worry. Sylvester had never come home later than dinner time. Where could he be? They stayed up all night wondering what happened, expecting that Sylvester would surely turn up by morning. But he didn’t, of course. Mrs. Duncan cried a lot and Mr. Duncan did his best to soothe her. But longed to have their dear son with them. “I will never scold Sylvester again as long as I live,” said Mrs. Duncan, “no matter what he does.” At dawn, they went about inquiring of all the neighbors.

They talked to all the children – the puppies, the kittens, the colts, the piglets. No one had seen Sylvester since the day before yesterday. They went to the police. The police could not find their child.

**Moment for Discourse and Debate #3:**

We have seen many different animals that live in Oakdale. If we were to go to Oakdale, what type of animal do you think we would find the most of living there? Tell me why you say that.

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that kittens will be the animal that we see the most? What do you think about that?

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

**NOTE:**
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about _______, does that change what you think about __________)

All the dogs in Oatsdale went searching for him. They sniffed behind every rock and tree and blade of grass, into every nook and gully of the neighborhood and beyond, but found not a scent of him. They sniffed the rock on Strawbeery Hill, but it smelled like a rock. It didn’t smell like Sylvester.

**Moment for Discourse and Debate #4:**

There are 21 dogs from Oakdale on these pages. If there are 3 more dogs in town that have not joined the search yet, what do you think that those three dogs would look like? Tell me why you say that.

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I know for sure that all three of the dogs will be spotted? What do you think about that?

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

**NOTE:**
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about _______, does that change what you think about __________)
After a month of searching in the same places over and over again, and inquiring of the same animals over and over again, Mr. and Mrs. Duncan no longer knew what to do. They concluded that something dreadful must have happened and that they would probably never see their son again. (Though all the time he was less than a mile away.) They tried their best to be happy, to go about their usual ways. But their usual ways included Sylvester and they were always reminded of him. They were miserable. Life had no meaning for them any more.

Night followed day and day followed night over and over again. Sylvester on the hill woke up less and less often. When he was awake, he was only hopeless and unhappy. He felt he would be a rock forever and he tried to get used to it. He went into an endless sleep. The days grew colder. The fall came with the leaves changing color. Then the leaves fell and the grass bent to the ground.

Then it was winter. The winds blew, this way and that. It snowed. Mostly, the animals stayed indoors, living on the food they had stored up. One day a wolf sat on the rock that was Sylvester and howled and howled because he was hungry.

Then the snows melted. The earth warmed up in the spring sun and things budded. Leaves were on the trees again. Flowers showed their young faces.

One day in May, Mr. Duncan insisted that his wife go with him on a picnic. “Let’s cheer up,” he said. “Let us try to live again and be happy even though Sylvester, our angel, is no longer with us.” They went to Strawberry Hill. Mrs. Duncan sat down on the rock. The warmth of his own mother waking from his deep winter sleep. How he wanted to shout, “Mother! Father! It’s me, Sylvester. I’m right here!” But he couldn’t talk. He had no voice. He was stone-dumb.

Mr. Duncan walked aimlessly about while Mrs. Duncan set out the picnic food on the rock – alfalfa sandwiches, pickled oats, sassafras salad, timothy compote. Suddenly Mr. Duncan saw the red pebble. “What a fantastic pebble!” he exclaimed. “Sylvester would have loved it for his collection.” He put the pebble on the rock. They sat down to eat. Sylvester was now as wide awake as a donkey that was a rock could possibly be, Mrs. Duncan felt some mysterious excitement. “You know, Father,” she said suddenly, “I have the strangest feeling that our dear Sylvester is still alive and not far away.” “I am, I am!” Sylvester wanted to shout, but he couldn’t. If only he had realized that the pebble resting on his back was the magic pebble!

“Oh, how I wish he were here with us on this lovely May day,” said Mrs. Duncan. Mr. Duncan looked sadly at the ground. “Don’t you wish it too, Father?” she said. He looked at her as if to say, “How can you ask that question?” Mr. and Mrs. Duncan looked at each other with great sorrow. “I wish I were myself again, I wish I were my real self again!” thought Sylvester. And in less than an instant, he was! You can imagine the scene that followed – the embraces, the kisses, the questions, the answers, the loving looks, and the fond exclamations!

When they had eventually calmed down a bit and had gotten home, Mr. Duncan put the magic pebble in an iron safe. Some day he might want to use it, but really, for now, what more could they wish for? They all had all that they wanted. The End.
APPENDIX D
Storytelling–Questioning Protocol (90th Street)

Storytelling – Questioning Protocol for Nothing Ever Happens on 90th Street

General Principles
1. Every Inference must be connected with a support – The Storyteller–Questioner must pursue EACH child’s reasoning with...
   1. Why? / Why do you think that? / What makes you say that?
   2. How sure are you about that? / Do you know that for sure?
2. Ask students to reflect on what others have said.
3. Ask students to reflect on a claim that the researcher presents.
4. Ask students to reflect on what they said in the past.

Coding for IIR Component the Questions Target:
   IIR1: Attending to Uncertainty
   IIR2: Making and Evaluating Claims
   IIR3: RelyingExplicitly on Data

STORY:
Begin by asking “What do you think that this book is about?”
(What makes you say that? How sure are you that you are right? What makes you that sure?) in order to start to establish norms for the conversation.

“Eva unwrapped a cinnamon Danish, opened her notebook, and stared helplessly at the wide, white pages. “Write about what you know,” he teacher, Mrs. DeMarco had told her. So Eva sat high on the stoop and looked over 90th street waiting for something to happen. A horn honked. A radio rapped. A kid cried. The usual. “Nothing ever happens on 90th street,” Eva scribbled in her notebook. A few doors down, Mr. Chang was arranging fish filets in his newly opened Seafood Emporium. No one was buying, and his shop looked as empty and ignored as the tiny, boarded-up store next door to it. He nodded to a woman passing by and called hello to Eva.

Moment for Discourse and Debate #1:

What if we knew that Mr. Chang sold 5 fish filets on Monday, 2 fish filets on Tuesday, 0 fish filets on Wednesday, and 3 fish filets on Thursday, how many fish filets do you expect that Mr. Chang will sell on Friday? Tell me why you say that.
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that he will sell ___ (choose something they didn’t)? What do you think about that?
(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

NOTE:
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ___, does that change what you think about _______)

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Out the door of Eva’s building came Mr. Sims, the actor, carrying his enormous cat, Oliver. Mr. Sims was “on hiatus again” which meant out of work, between shows, and so, every day, dressed in his finest, he embarked on a daily promenade with Oliver under his arm. “Writing?” he asked. “Trying to,” Eva answered, “but nothing ever happens on 90th street!” “You are mistaken my dear,” Mr. Sims said. “The whole world’s a stage – even on 90th street – and each of us plays a part. Watch the stage, observe the players carefully, and don’t neglect the details,” he said, stroking Oliver. “Follow an old actor’s advice and you will find you have plenty to write about.” “Thanks,” Eva said, and fast as she could, using as many details as she could recall, Eva described Mr. Sims in her notebook – his felt fedora hat, his curly gray hair, his shiny button shoes. When she looked up, he was halfway down the street and Mr. Morley, the mousse maker, was at his window.

Just as he did every day, Mr. Morley set his chocolate pot and coffee urn out on his ledge with a sign. Mr. Morley dreamed of having a catering business where the fanciest people demanded his dessert. But the trouble was … Mr. Morley’s mousse was missing something. No matter how he tried, his mousse never has much taste, and Mr. Morley never had many customers. “Writing?” he asked. “Um. Hmmm,” Eva answered, chewing on her pencil. “Try to find the poetry in your pudding,” Mr. Morley said softly. “There’s always a new way with old words.” “You’re right,” Eva said, wishing Mr. Morley would one day find the poetry in his pudding. Taking his advice, she tried to think up a new way to describe the look of Mr. Morley’s mousse. Smooth and dark as midnight. Or maybe more like mink! Yes, that was it! Eva thought, writing in her notebook.

MOMENT #2
What are you thinking about now?

What other sorts of people do you think that Eva will meet as she continues down the street?

The door to the building slammed and a gust of wind sent data leaves soaring and dipping like crazy kites. Alexis Leora nodded to Eva and stepped gracefully down the steps to her warm-up exercises. Alexis was a dancer. When she wanted to, she could hold an extremely long leg straight up against her ear like a one-legged woman with three arms. But she couldn’t smile. Eva decided it was because Alexis Leora was lonely. “Writing?” Alexis Leora asked Eva. “Yes,” Eva answered. Alexis Leora did six deep knee bends and then sighed. “Stretch,” she said sadly. “Use your imagination. If your story doesn’t go the way you want it to, you can always stretch the truth. You can ask, ‘What if?’ and make up a better story.” “You’re right,” Eva said, thinking “What if?” and make up a better story.” “You’re right,” “What if?” What if Alexis Leora met someone? Would she smile then? What would that look like? Eva closed her eyes to try to picture it, but all she could picture was soup – Spanish soup – rich and brown and so spicy it seemed as if she could actually smell it.

She could! When Eva opened her eyes, Mrs. Martinez was standing beside her. She nodded to Alexis Leora as she handed Eva a bowl of soup. “Have some,” she said. “Writers need soup. What’s your story about?” “Nothing much,” Eva sighed. “Nothing ever happens on 90th street.” “Add a little action,” Mrs. Martinez said. “Like soup. A little this. A little that. And don’t forget the spice. Mix it. Stir it. Make something happen. Surprise yourself!” She nodded again to Alexis Leora and went inside. Eva put down her pencil and tasted Mrs. Martinez’s wonderful surprising soup. She thought about her story. It wasn’t wonderful. It wasn’t surprising. But what could she do? Nothing ever happened on 90th street. How could she possibly “add a little action” and “make something happen”? Eva had no ideas. She was stuck!

Then Mrs. Friedman from up the block came wheeling Baby Joshua in his stroller. He was holding a bright red ball in two tiny, fat hands. “Bird!” he called out to a pigeon hunting for something to eat. “Bird.
Hungry!” “Pigeon,” Mrs. Friedman told him. Eva sighed and looked down at her half-eaten Danish, then at her notebook. She looked at Baby Joshua, then at the pigeon. She remembered Alexis Leora’s words of advice. “What if?” Eva thought. Suddenly she had an idea. What if she stood up, broke her Danish into dozens of pieces, and scattered them wide and wild into the street? What would happen? Eva laughed to think of it …

**Moment for Discourse and Debate #2:**

*So far on 90th Street we have met 7 females (girls) and 3 males (boys)? If we keep walking down 90th Street and we run into 10 more people, what gender do you expect them to be? Tell me why you say that.*

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that all 10 people will be boys/girls (whatever they didn’t say)? What do you think about that?

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

**NOTE:**
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about ________)

From lampposts and ledges dozens of pigeons swooped down to dine on Danish. Eva eagerly picked up her pencil and began to write again. “Bird!” Baby Joshua called out, pointing. “More bird!” he cried, panting. The bright red ball dropped out of his tiny, fat hands and bounced onto the sidewalk. “Bye, bye ball!” Baby Joshua screamed. The ball rolled off the curb, into the street, and straight into the path of a pizza delivery man on his bicycle!

**Moment for Discourse and Debate #3:**

*Take a look at these pizzas. Notice the pepperonis on the pizzas. How many pepperonis do you think are on the pizza in the box that he didn’t spill? Tell me why you say that.*

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

What if I said that I think that there will be 20 pepperonis on the pizza in the box? What do you think about that?

(What makes you say that? How sure are you that you are right? What makes you that sure?)

What do you think about what he/she said? (How likely do you think it is that that would happen?)

**NOTE:**
(For students whose claims and support are not built on the data from the story. Point out some specific data and ask them if they think about ______, does that change what you think about ________)

Everyone gasped in horror. Alexis Leora paused in mid-plie and leaped to the rescue. She got there just as the pizza delivery man landed, right side up, at her feet. Alexis Leora looked down at the pizza man and he
looked up at her. And then something almost unimaginable happened: Alexis Leora smiled! “Are y-y-you all right?” she asked, shyly. Her smile was sweet and bright. Her teeth were straight and white. (It was the first time Eva or anyone on 90th street had seen them.) “Yes,” said the pizza man, smiling up at her. It was love at first sight. Pepperoni and peppers rained down on the happy couple. The pizza man pulled a pepper out of his hair as horns began to honk. Eva added this to her notebook and wondered what could possibly happen next …

A long, white limousine was honking its horn loudest of all. The limo driver rolled down his window. “Whad’ya wanna block traffic for?” he called out. The back door of the limo opened and out stepped a woman in sunglasses, wearing a turban and a coat the color of a taxi. “There seems to be a problem, Henry,” she said in a fake English accent. “There’s some sort of accident here. Perhaps’ “It’s Sondra!” someone suddenly screamed, interrupting her. “Sondra! Can I have your autograph?” Mrs. Martinez called out. “Sondra Sauderson!” Mr. Morley blushed. Was Eva dreaming? There, in the middle of 90th street, larger than life, stood Sondra Saunderson, star of stage, screen, and the sensational soap opera “One World to Live In.”

“Darlings, what’s happening here? I’m sure I … Lar-ry!” she called out suddenly, and stretched her arms toward Mr. Sims, who had just returned from his promenade. “It’s been an age since we saw each other!” Mr. Sims’ cat, about to be crushed in an extravagant embrace, leaped out of Mr. Sims’ arms to chase after Baby Joshua’s ball. “Oliver!” Mr. Sims called out. “Come back!” Everyone raced into the street after the ball, but it was the limo driver who, in the right place at the right time, leaned into the gutter and picked it up.

With a flick of the wrist, he tossed the ball to Mr. Friedman, who presented it to a drooling but grateful Baby Joshua. “How’s that for a throw?” the limo driver proudly asked the crowd. No one, not even Baby Joshua, had a chance to answer. Oliver, freighted by so many people, raced past Eva, scrambled onto Mr. Morley’s ledge, where he knocked over his coffee urn, spilling all the coffee into his mousse pot. “Ruined!” Mr. Morley cried, wringing his hands. At that, Oliver bounded to the top of a ginkgo tree, where he swayed dangerously like a heavy white balloon. “Now he’ll never come down!” Mr. Sims lamented. “He’s terribly stubborn.” “There, there, Larry,” Sondra Saunderson confronted him. “I’m sure someone on 90th street will have a solution.” Eva tried to imagine who that could possibly be …

“I have one!” she heard Mr. Chang call out. Generously, he offered trout, fresh from his store, to Oliver. High up in a tree, Oliver barely blinked. “Raw trout? Mr. Sims sighed. “My regrets, Mr. Chang. He won’t eat it. He’s a gourmet cat. I’m afraid I’ve spoiled him. Whatever will I do?”

“What if?” Eva asked herself for the second time that day, and suddenly she had another idea. A truly great one! She whispered it to Mr. Morely, Mrs. Martinez, and Mr. Chang. “Brilliant!” Mr. Morley exclaimed. And with that he, Mrs. Martinez, and Mr. Chang, still clutching his trout, vanished into the building. Eva righted Mr. Moreley’s coffee urn and stuck her finger into the ruined mousse, then into her mouth to determine the degree of the damage. “Mocha!” she called out in surprise. “Mr. Morley’s mousse is mocha now and …” She paused, trying to find the perfect word. “Magnificent!” She announced to the assembled throng. And, giving the pot a stir, she dished out samples to all assembled. “Delicious!” Alexis Leora said, spooning some into the pizza man’s mouth. “Poetry!” Sondra Saunderson pronounced.

Now on 90th Street, people who had never spoken to one another before were speaking at last. The pizza delivery man and the limo driver shook hands, and everyone tried to tempt Oliver down from his precarious perch. And then … Mr. Morley appeared on the steps, followed by Mrs. Martinez and Mr. Chang. Mrs. Martinez carried a large pot of her surprising soup, while Mr. Morley carried a platter of Mr. Chang’s trout, now surrounded by many tiny vegetables and cooked to perfection. With the addition of a cup of Mr.
Morley’s cat-created mocha mousse – it was a meal worthy of the finest culinary establishment. “Do you smell that, Oliver?” Mr. Sims called, fanning the steam so it rose up the ginkgo tree.

Oliver took on deep sniff and bolted down the tree to dine! Everyone on 90th Street sampled each course and everyone on 90th Street sighed with delight. “Supurb!” “Fantastic!” “Yum!” Eva smiled and glanced up from her notebook. For the third time today she asked herself, “What if?” “Mr. Chang,” she began, “you and Mr. Morley and Mrs. Martinez are such great cooks. The boarded-up store next to your Seafood Emporium, what if all of you used it for a restaurant?” “A restaurant?” The three chefs looked at one another. “What a wonderful idea,” they said, shaking Eva’s hand. “Everyone on 90th Street could be our customers. You too, Sondra.”

“No longer!” Sondra called out. “You’ll be on my show! I’ll arrange it.” Mr. Sims kissed Sondra’s hand, and everyone cheered. “What an amazing day!” Mrs. Martinez said, “Who would believe it?” If only someone had written it all down. “I did,” Eva announced and she opened her notebook and began to read her story (the same story you are reading now) about how nothing ever happened on 90th Street. “What a story!” Sondra exclaimed. “Full of detail. Dialogue. Suspense. A bit of poetry. A hit or romance. Even a happy ending. Why, you’d almost think some of it was made up!” Eva smiled mysteriously, “Thanks,” she said proudly. “But just wait. It’ll be even better…after I rewrite it.”
Date: October 7, 2013

To: Kate Kline, Principal Investigator
Dustin Smith, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 13-09-18

This letter will serve as confirmation that your research project titled “Eliciting Early Elementary School Students” has been approved under the expedited category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study.”) Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 7, 2014