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Math Stories in Elementary Mathematics Education in China and North America

Bingqing Xu, *The University of Western Ontario*

Supervisor: George Gadanidis, *The University of Western Ontario*

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ABSTRACT

In our information- and technology-based society, mathematics education plays an increasingly important role in current world economic development. As the world's biggest economies, China and North America have accelerated the reform of mathematics education in recent years. One phenomenon is that children's literature has attracted great attention in the improvement of mathematics instruction and students' learning for early childhood education. However, research conducted on math literature and the comparison of math literature in China and North America is limited, which points to the necessity of considering the similarities and differences of math literature in China and North America. By comparing and contrasting math stories in China and North America, this study presents similarities and differences of math stories. After analyzing the findings with attention to underlying differences between stories, it appears that features of each respective math education system are also reflected in the differences between math stories in China and North America. Chinese math stories are less developed than those in North America, as well. To illustrate the differences, this study also puts forward criteria of good math stories and illustrates how to rewrite a Chinese math story to better meet these criteria. In the light of the findings, implications and recommendations for the development of math stories are provided.

Keywords: math stories, China, North America, elementary mathematics education, international comparisons

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TABLE OF CONTENTS

LIST OF APPENDICES

Appendix **Page**

LIST OF FIGURES

LIST OF TABLES

Tables **Page**

CHAPTER 1: INTRODUCTION

This chapter gives a brief overview of this study. Specifically, this review introduces the rationale and background of the study as a context. Then, it presents the purpose and question of the study, the significance of the study, and the limitations of the study. Furthermore, it outlines the following chapters of the study.

1.1 Rationale

Although the use of children's literature in elementary school is common, especially in earlier grades, the use of math stories is less common. I have learned that elementary teachers in Canada occasionally use children's literature in teaching mathematics. Thinking back to my elementary school experience as a student and as a teacher in China, I don't remember being introduced to children's math literature. However, through recent Internet searches I have found a large amount of children's math literature in China. In this context, I am interested in comparing and contrasting the math stories in China with those in North America.

1.2 Background

In today's world of rapid change, particularly in terms of technological change, demand for mathematical skills is increasing. Many programs of study use mathematics performance to assess students' academic ability. It is suggested that "mathematics is crucial for economic development and for technical progress" and the improvement of mathematics education would increase a country's competitiveness in the world economy (Advisory Committee on Mathematics Education [ACME], 2011, p. 4). It is also generally agreed that mathematics is a core skill for life, which sometimes can influence

an individual's job prospects. China and North America, as the world's biggest economies, have placed great emphasis on the development and improvement of mathematics education in recent years (Doctorow, 2002).

When it comes to mathematics teaching, there is much concern about students' mathematical competence. It appears that students could make improvements in the mastery of basic facts with no evident progress in the areas of problem solving and critical thinking (Whitin, 1992). This phenomenon shows that students can be competent at manipulating numbers and symbols, but have difficulties in solving the same problem when it appears in another form, for instance, in a word form; such difficulties eventually make many students dislike mathematics. On the other hand, when the subject of mathematics teaching is discussed, workbooks, manipulatives and calculators are always regarded as important resources for teaching students effectively while literature is not often on the resources list (Golden, 2012). Children's literature is frequently used in history, arts and language classes; the use of literature in mathematics instruction is more likely to be ignored or overlooked.

However, with the development and innovation of mathematics education, children's literature has drawn more attention in recent years. In North America, according to the document *Curriculum Focal Points For Prekindergarten Through Grade 8 Mathematics* released by the National Council of Teachers of Mathematics (NCTM, 2006), students are required to do more reading, writing and discussion of mathematical ideas, which in part has increased the use of math stories. In order to implement the NCTM standards, many scholars and educators suggest that teachers use printed materials, such as picture books, chapter books, poems, and newspapers. On the

other hand, although textbooks reflect the curriculum standards, the explanations are often too dry to stimulate positive interactions. Teachers are encouraged to create an interesting lesson by, among other activities, using children's literature as a stimulus for mathematics learning.

In China, with the reform of Chinese Mathematics Curriculum, much more attention has been focused on the improvement of students' problem-solving ability, which increases the focus on the quality of mathematics teaching and learning. Many students feel mathematics learning is not interesting and teachers are under great pressure to teach mathematics differently, which shows the need of integrating new concepts like stories to vitalize mathematics class (Lu, 2014).

Some literature in China and North America suggests that children's stories can have a positive impact on mathematics instruction and students' learning in the elementary grades (Chen, 2014; Gadanidis. G., Gadanidis. J. M., & Huang, 2004; Whitin, 1992; Xu, 2014). Even though these are not empirical studies on how stories have a positive impact on learning, they do still provide support for this study. Even though in both China and North America many children's mathematics literature books are available, few research studies have been conducted on mathematics literature, and the comparison of mathematics literature in elementary school in China and North America is limited, which points out the necessity to consider the similarities and differences in mathematics literature in China and North America.

1.3 Research Purpose and Question

The purpose of the study is to extend existing research by answering the following research question: what are the similarities and differences of math stories in elementary mathematics education in China and North America? This question will be investigated from three perspectives: physical characteristics, plot development, and mathematical development.

1.4 Significance of the Study

Previous mathematics articles have indicated that children's literature, as an effective tool to stimulate students' interest, has great effects on the quality improvement and innovation of elementary mathematics education (Lou, 2011; Murphy, 1999; Whitin, 1992; Zou, 2011). Thus, it is necessary for teachers to choose some math stories and integrate them into mathematics instruction. However, the use of math stories appears to be much more common in North American classrooms, and few math stories have been integrated into mathematics classes in China. For example, a scan of North American professional mathematics education journals for elementary mathematics reveals that there is a focus on math stories in mathematics teaching, especially in the early grades, but this focus is lacking in China. This difference between North America and China indicates that it might be interesting to investigate comparisons between North America and China. Few studies have been conducted to compare education in North America and China (Chang, 2014), and even fewer to compare the use of stories. This study will help address this gap in education research. The findings of the study may provide implications for the design and application of math stories in mathematics instruction,

and for the improvement of elementary mathematics education in both China and North America.

1.5 Limitations of the Study

Several limitations of this study have been identified and should be considered when interpreting the findings as well as conducting future research.

First, the comparison of math stories focuses on math stories themselves. In this study, I explore the similarities and differences of math stories in China and North America through reviewing and coding specific math stories based on physical characteristics, plot development and mathematical development. This study lacks the comparison of how math stories are used in mathematics classrooms in China and North America.

Second, this is a qualitative study whose sample size is small in scale and the findings are not generalizable. In this study, I compare 20 Chinese and 20 North American math stories which are a small sample size and a convenient sample. No claims are made that this is a valid, representative sample of math stories in China and North America. Also, because the data (math stories) of this study are all selected by the researcher, biased selectivity is unavoidable.

Third, misinterpretations are likely to take place when translating Chinese math stories into English. My own values and understanding of the story might be imposed on the findings.

Fourth, document analysis is the main research method of this study and there is a lack of fieldwork. Documents do not always provide sufficient details and those documents may be influenced by authors' views and values (Bowen, 2009; Mills, Durepos & Wiebe, 2009).

Lastly, it is important to note that this thesis will use constructivism as its theoretical framework. Constructivism is a theory chosen from Western culture, and the judgments made in this thesis based on this theory about the nature of stories in China may introduce a cultural bias.

1.6 Organization of the Study

In the second chapter, I discuss the literature that deals with the mathematics education system and existing research about math stories in China and North America. In Chapter three, I describe the theoretical framework and methodological approach of this study in detail. Chapter four elaborates the findings of this study which consists of the specific themes that emerged from the data analysis. In Chapter five, I interpret and discuss the findings of the study in light of my original focus. Chapter six outlines implication for the development of math stories, as well as considerations for future research based on this study.

CHAPTER 2: LITERATURE REVIEW

This chapter focuses on a review of educational research that attempts to provide an answer to the question: What is the present situation of math stories in elementary mathematics education in China and North America? In the search for the answers to this question, the literature review branches out into two sections: (1) the mathematics education system in China and North America; and (2) what other scholars have written about the use of stories in mathematics education.

2.1 Math Education System

This section will introduce the math education system which will be categorized into three sub-sections: mathematics teaching and learning in China and North America, the nature of mathematics, and the learning environment.

2.1.1 *Mathematics teaching and learning in China and North America*

In this section, the role of students and teachers in mathematics class, mathematics classroom instructions, mathematics curriculum, and the effect of mathematics textbooks on teaching and learning in China and North America will be introduced individually.

Chinese mathematics teachers play the role of director of learning, carefully control what to teach, how to teach and at what pace (Hattie, 2009; Norton & Zhang, 2013), in North America, mathematics teachers also play the role of a facilitator (Pang, 2000). In China, teachers take the centralized curriculum as an important agenda, while not catering to individual differences among students (Cheng, 2004). Due to the severe competitiveness of the entrance of senior high school and colleges, Chinese mathematics teachers feel that they have no choice but to give students lectures, teach them how to

take tests and test them with examinations which pay more attention to the technique of test-taking rather than the content of mathematics (Chang, 1984). Teachers are considered as persons of authority who are experts in knowledge and skills, have sincere moral behavior and know the answer to every question (Grant et al., 2014). In North America, teachers give students directions for further thinking when they misunderstand concepts (Pham, 2015), and they are more likely to play the role of questioners who hold back their own opinions and strive to evoke student thinking (Pang, 2000), and enhance student participation and achievement.

Accordingly, the role of students in mathematics class is in line with the role of teachers. In China, due to the influences of Confucian Heritage Culture and Maoist Politics, learning essentially is related to the realization of personal virtue, moral and obligation (Norton & Zhang, 2013). On one hand, Chinese students observed by Western researchers are deemed to have disciplined behavior and concentrated attention in mathematics classroom, along with the teacher-centered and text-based interactions (Jin & Cortazzi, 2008; Marton, Dall'Alba, & Tse, 1996). On the other hand, Chinese students are accustomed to the learning process that involve memorizing the material initially, and leaving for later seeking to understand the definition and function of the material, trying to apply their understanding to build connections between such knowledge and different context, and raising questions and modifying their previous understanding (Li, 2004). By contrast, An (2008) and Grant et al. (2014) report that students in North America have more positive and enjoyable experiences in their mathematics class where they actively participate in individual or group work. In addition, North American students are always

encouraged to engage in specific mathematical activities to express their own ideas, such as explanation, justification, and argumentation (Pang, 2000).

Based on Lim's (2007) observation and Wong's (2004) analysis, Chinese elementary mathematics class especially emphasizes discipline, which appears to be a teacher-centered teaching method; however, the teaching and learning activities in North American classroom are much more student-centered. In Chinese mathematics classes, lessons are dominated by teachers' talk (Paine, 1990). The traditional lecture-delivered teaching method is regarded as the most common one in mathematics teaching in China (Pang, 2000). In addition, due to the effect of Chinese culture, mathematics instruction in China focuses on demonstration, computation, repeated drilling, memorization, and skills which are regarded as the vital foundation and prerequisite for the learning of problem solving (Biggs, 1991, 1994; Jin & Cortazzi, 2008; Zhang, Li, & Tang, 2004). Compared to the situation in China, instruction in North American uses more manipulatives and real-life projects in the classroom, which North American teachers believe would motivate students in mathematics learning and help students make a connection between concrete and abstract math content (An, 2008; Pham, 2015). What's more, most mathematics classrooms in the United States also use audio and visual representation, self-paced learning, and computer-assisted learning instruction during their presentations while this is not very common in China (Chang, 1984). In addition, mathematics teaching in North America places greater importance on integrating literature and various subjects into mathematics lessons; however, Chinese mathematics teachers are specialized in their own subject area and the different subjects are not integrated (An, 2008). According to Kaiser, Hino, and Knipping (2006) and Rittle-Johnson, Siegler, and Alibali (2001), the

approach of Chinese mathematics teaching is closely related to the "scientific understanding of theory" which means "theoretical mathematical considerations are of great importance." It can be said that Chinese mathematics teaching focuses on the subject structure of mathematics and the theory "is made explicit by means of the theorems and formulae" (Kaiser, Hino, and Knipping, 2006, p. 328), and emphasizes more on the improvement of basic skills. However, North America's approach is more related to "pragmatic understanding of theory" which means "a practical and purposed-depending handling of theory" (Kaiser, Hino, and Knipping, 2006, p. 329). This can be seen from the introduction of concepts, the process of proof and justification and the use of precise language which indicates that North American mathematics teaching pays more attention to the procedural skills and conceptual understanding of mathematics.

Both Chinese and North American mathematics curricula for elementary students offer pedagogical suggestions. With the reform of "The Mathematics Curriculum Standards for Full-time Compulsory Education" in China (Ministry of Education, 2011), the emphasis of suggested teaching approaches in Chinese Mathematics Curriculum Standards shifts from high requirements of students' computational ability to enabling students to abstract mathematics knowledge from real life problems, explore the fundamental discipline behind the mathematical knowledge, and use different ways to complete problem solving (Zhang, 2005). According to Yu (2009), Chinese mathematics teachers are expected to emphasize "the introduction of new concepts and methods, the position and function of proofs, and the role of precise language" (p. 83). Even though this reform proposed to decentralize the curriculum and advocate school-based curriculum, the governance of the curriculum is still not localized (Gao, 2014). Compared

to the centralized curriculum in China, North American's curricula have fewer restrictions and they put more effort into helping students build solid conceptual foundation in mathematics so as to further their development. For instance, the emphasis of the United States' Mathematics Curriculum is to improve students' problem-solving skills (Norton & Zhang, 2013) which requires students to solve and also pose problems, as well as reasoning and proving (Ruddock & Sainsbury, 2008). In Canada, taking the province Ontario as an example, Ontario's Mathematics Curriculum highlights the development of students' mathematics understanding of "big ideas" that interrelate concepts and help develop learning mathematics in coherent way (Ontario Ministry of Education, 2005). The Ontario document also refers to connecting math concepts with children's literature and real life situations, and developing students' ability to reflect on their own thinking processes. Overall, the Chinese mathematics curriculum is experiencing a transition period which is shifting its attention from memorizing to understanding concepts, while North American's curricula start to adopt new educational philosophy and material, like "big ideas" and children's literature, to improve the quality of mathematics education.

As the primary resources for students and teachers, textbooks have a great influence on classroom instruction and suggested pedagogical approaches (Cady, Hodges, & Collins, 2015; Cady, Meier, & Lubinski, 2006; Valverda, Bianchi, & Wolfe, 2002). Frase (1997) reports that China has a national curriculum and textbook, while the countries in North America, including the United States and Canada, do not have a centralized curriculum and textbook. This means that each province or state in North America has its own curriculum and textbooks which mean a large variety of textbooks use across each

country. In other words, teachers in China have no choice to choose textbooks, while in North America, teachers in different schools could select different textbooks (Ma, 1999). On the other hand, from the aspect of content, textbooks in China and North America are both computation-dominated, as Ding and Li (2010) reported. The textbooks both in China and North America also provide a considerable number of problems and heuristic solutions for students to develop their problem solving ability (Zhu & Fan, 2006). Chinese textbooks focus on the underlying principle behind the instruction and tend to cultivate students to use convenient ways to compute solutions (Ding & Li, 2010). The textbooks in North America have more types of innovative and non-traditional problems and tasks which could contribute more to students' understanding than the traditional, rule-based problems designed in Chinese textbooks (Siemon, Virgona, & Corneille, 2001). What's more, the Chinese textbooks include more multiple-step and challenging problems while North America's provide less challenging problems in terms of the number of steps involved in the problems' solutions (Harding, 1995). Three major critiques of American textbooks are summarized as too many topics, repetition and overlapping of content, and later introduction of topics in the elementary levels (Erbas, Alacaci, & Bulut, 2012; Kang, 2014; Kim, 1993; Porter, 1989).

Based on this review of the situation of mathematics teaching and learning in China and North America, we can see that in China, teachers are directors and students are passive learners who are accustomed to disciplinary behaviors, while in North America, teachers are more likely to be facilitators and students are encouraged to do self-expression. The role of teachers and students in class influences the teaching method. Mathematics teaching in China is teacher-centered, while a student-centered teaching

method is more common in North America. This is also reflected in the development of curriculum and textbooks:Chinese curriculum and textbooks are centralized and still need to be improved while North Americans' are more localized by state or province and more progressive as indicated in research reports and described in the curriculum documents. However, mathematics textbooks in China tend to address more challenging topics than those in North America.

2.1.2 The nature of mathematics

Teachers' thinking about the nature of mathematics determines the approaches and models of their teaching which could form their teaching and learning philosophy (Azim & Ahmed, 2014). Chinese mathematics emphasizes the education of basic knowledge and skills, which is taken as the foundation for high level learning (Cheng, 1999; Cheng, 2004). However, the nature of North American mathematics focuses on the individual learner, which suggests that students can learn best when they are engaged in exploration first and then continue to develop an understanding of concepts (Biggs, 1996). In China, the development of evaluation, analysis and creative ability can only be demonstrated when the students have the prescribed and approved performances in basic formulae memorization and computation ability (Cheng, 2004). Chinese educators believe that the understanding of the content occurs before the creative exploration (Biggs, 1996). Therefore, mathematics for the elementary students in China focuses more on the computation skills and the definition of concepts while mathematics in North America pays much more attention to the understanding of mathematical concepts and the development of critical thinking (Cai, Lin, & Fan, 2004).

Ernest (1989) points out three philosophies of mathematics: Instrumentalist, Platonist and Constructivist. In the constructivist view of mathematics teaching, mathematics could be created and constructed and teachers work as a guide and facilitator during the construction of mathematics knowledge for students rather than show students the answers or solutions directly (Azim & Ahmed, 2014). Although mathematics education in China and North America both place an emphasis on students' development of logical reasoning which could help students construct their mathematical knowledge, mathematics education in North America provides more variety of non-traditional and non-routine problems during instruction for students than Chinese mathematics teaching, which mostly includes puzzle problems (Zhu & Fan, 2006). In addition, more contextualized contents with real life situations are added in North America's teaching. Compared to North America's mathematics teaching, Chinese mathematics teachers have a high expectation of students at the early level and through their teaching provide a higher level of difficulty in the content (An, 2008). Hence, the nature of mathematics in China is to develop students' basic knowledge and skills by adding the difficulty and quantity of exercises and content; however, mathematics in North America attaches importance on the improvement of students' conceptual understanding and creativity ability by using various manipulatives and hands-on activities during the instruction (Biggs, 1996).

2.1.3 Learning environment

The learning environment of mathematics classes is very different in China and North America. In China, the learning environment of the mathematics classroom is typically described as "crowded, large class size, passive learners, and dominant

teachers" (Biggs, 1991, 1994). However, the learning environment in North American classes is more flexible, with more freedom for students and more opportunities for collaborative work and student-to-student interactions (Biggs, 1996). Chinese schools have larger classes than North American classes, with each classroom having as many as 40 to 50 students-almost twice the size of the typical North American class (Sztein, Olson, & Ferreras, 2010). Students in China sit in rows of desks facing the teacher, however, the desks in North America may be clustered into groups so that students could work collaboratively (Fang & Gopinathan, 2009; Huang &Leung, 2004). Influenced by the Confucian Heritage Culture and Mao Zedong's policy, discipline and attention are much valued in Chinese learning environment (Frederick, 2004; Jensen, 2012; Wong, 2004). In Chinese classrooms, teachers lead nearly all of the classroom activities and do most of the talking to reticent students, and students conform to a uniform standard of behavior (Paine, 1990). In contrast, North America's teachers are expected, as evinced in the curriculum documents, to promote opportunities for students to actively participate in mathematics activities in class, and students are encouraged to share their reasoning with others to improve their problem skills and conceptual understanding. Teachers in Chinese math classrooms are like performers, and students are like audiences. The learning environment in North America is more interactive, with increased interactions and student participation.

In summary, the Chinese mathematics education "is highly examination-oriented, encourages conformity, discourages the development of students' creativity, and bolsters authoritarian teachers" (Grant et al., 2014, p. 4). With the reform movement of national education, the educational system is attempting to give more autonomy to students and

teachers and transfer from a “test-oriented” to a “quality-oriented” system, but it is still at an early stage. Compared to China, the mathematics education system in North America encourages students’ self-expression and exploration to move to the understanding of concepts and development of skills, and promotes teachers’ using children’s literature and manipulatives to their instruction innovation.

2.2 What Other Scholars Have Written

According to the papers about math stories found in China and North America, four categories will be described in this section: stories in China and North America, the advantages of using math stories, ideas for using specific stories in math teaching, and what makes a good story.

2.2.1 Stories in China and North America

There are more scholarly papers about math stories in North America than in China. Accordingly, the number and variety of math stories in North America is also much greater than in China. In North America, I found 619 papers and studies about math stories with search words “math stories” and 169 articles with search words “children’s literature and mathematics” in the database ProQuest-Education. This is much more than that in China where I found 432 articles in total listed in the largest and most professional database, CNKI (China National Knowledge Infrastructure) in China. However, if we are looking at the math stories search results in the last five years in the same way, we can find that in North America, 198 results are listed with search words “math stories” and 51 articles are showed with search words “children’s literature and mathematics” in the database ProQuest-Education, which accounts for approximately 30% of the original research results. However, 287 articles about math stories in China in last five years can

be found which takes up almost 66% of the previous research results. From this point of view, there seems a smaller gap in recent years in the development of math stories in China and North America. Though China has few scholarly papers about math stories in total, it is improving rapidly in recent years. Thus, it may not be relevant to look at scholarly papers about math stories in volume between the two regions. On the other hand, the results for "math story books" in Amazon.com numbers 4629 in North America, while only 441 results are shown on the Chinese website "Dangdang," which is one of the biggest online bookstores in China.

Here are some commonly cited math story books in North America: *Anno's Magic Seeds* (Anno, 1999), *Grandfather Tang's Story* (Tompert & Parker, 1990), *Missing Mittens* (Murphy, 2000), *Sir Cumference and the Dragon of Pi* (Neuschwander, 2013), *The Doorbell Rang* (Hutchins, 1986), *The Action of Subtraction* (Brian, 2008). In China, *Ma Xiaotiao Play Mathematics Series* (Yang, 2010) and *Li Yupei Mathematical Tales Series* (Li, 2000) are the most famous children's literature in mathematics education (Chang, 2014).

From the perspective of the genre of children's literature, most math stories in China are narrative stories and few are science fiction, which is similar to those in North America (Chang, 2014). Both in China and North America, some math story books are divided by the strands of mathematical knowledge, and the number of math stories in Number Sense and Numeration, including number counting, addition and subtraction, multiplication and division, even and odds, fraction, are more than those in Measurement, Data Management, Patterning and Geometry (Lou, 2011). In addition, some of the math stories in China and North America are also separated by the grades of elementary school.

2.2.2 The advantages of using math stories

Stories have been regarded as an important and powerful vehicle for improving teaching and learning in elementary school for a long time, especially in the earlier grades. Both researchers from China and North America are studying the use of math stories in elementary education.

In China, most researchers state three benefits of using math stories in class (Chen, 2014; Lou, 2011; Wen, 2014; Zou, 2011). The first is that stories play an important role to motivate students' interest and enthusiasm in mathematics learning. The second merit is that stories have the function to simplify difficult mathematical knowledge which is hard for teachers to explain clearly and for students to understand easily. Math stories could embody the math concepts in a lively form, which is more suitable for engaging elementary students. Third, connecting math stories with exercises typically found in math textbooks could help students better understand the key ideas of mathematics. The first two advantages of math stories are supported by research in North America (Golden, 2012; Murphy, 1999), as some North American scholars also point out that children's literature could help students to become good problem solvers, to communicate mathematically and to improve the ability of reasoning in math (Whitin, 1992). Also, math stories are full of plots and details which can enhance the abstract math knowledge with entertainment that can not only stimulate students' interest and pleasure but also help them understand the knowledge more deeply (Gadanidis. G., Gadanidis. J. M., & Huang, 2004). At the same time, the content and language in children's literature are usually informal and easy to comprehend, which could increase students' enthusiasm for the mathematical concepts that go along with stories (Greenlaw & Tipps, 1997).

Children's literature presents math concepts in a natural way and creates opportunities for students to discover math which would lead to the improvement of the ability in problem solving (Bruce, 2007). In addition, math stories can also help students connect mathematical ideas to their own lives (Murphy, 1999). These advantages of using math stories are mentioned in North America's research frequently while rarely studied in Chinese papers.

Research in both China and North America indicate that integrating children's literature into mathematics class could motivate students to participate in mathematical activities and provoke their interest in mathematics (Chen, 2014; Murphy, 1999; Wen, 2014; Whitin, 1992). Children's literature is regarded as an accessible and positive vehicle for students to learn mathematics both in China and North America (Chen, 2014; Murphy, 1999). However, Chinese researchers lay an emphasis on arousing the interest of students, which could improve the quality of mathematical teaching and learning (Lou, 2011; Wen, 2014). However, research studies in North America pay more attention to helping students discover math and teaching them to solve a problem in more than one way (Bruce, 2007). They also consider that students could explore the mathematical concepts in a variety of real life situations by integrating math stories (Gadanidis. G., Gadanidis. J. M., & Huang, 2004). Helping students become problem-solvers is a significant point in North America's existing research, while Chinese scholars make great efforts in stimulating students' interest. Therefore, there exist some differences between China and North America in terms of the use of math stories that will be discussed below.

2.2.3 Ideas for using specific stories in math teaching

How teachers view the benefits of using math stories would influence their teaching methods in practice. Chinese research in this field can be separated into two parts. First, most scholars refer to how to use math stories throughout a whole mathematics class because of the large size of class in China (40-50 students). Researchers in China (Liu, 2014; Lou, 2011; Xu, 2014) report that math stories should be used in four phases in a math class which first emphasizes using math stories about the topic of that class at the beginning of the class so that students' interest could be stimulated. Then, during the class, stories can be used to help students understand the difficulties by making connections with real experiences or creating their own stories. When doing exercises in the class, stories are promoted to be integrated into specific concepts of math problems which assist students with better understanding. At the end of the class, when student attention may be waning, especially in younger grades, teachers can use math stories to drive their interest. On the other hand, Lu (2014) points out the importance of creating interactions between students and math stories. Storytelling as a pedagogy could appear in a variety of forms, which is not limited to tale telling, but also includes story performance. The form of tale telling can also be in various forms, such as students retell the story and engage in role rehearsal. Students are encouraged to engage in the mathematics activities in class. Schools are advised to provide more books about math stories in the library for students (Chang, 2014). Chinese scholars also propose that teachers should be careful to combine stories with mathematics instruction effectively, as the benefits of using math stories are limited and teachers need to avoid using children's literature blindly (Liu, 2014; Wen, 2014).

Researchers in North America put forward some other ideas of using math stories. Students are encouraged to discuss the mathematics concepts with their real life situations, choose what they are interested in and create a new model, and think what else they could discover or what could happen next (Greenlaw & Tipps, 1997). Gadanidis and Hughes (2011) suggest taking children's literature as a starting point for investigating big math ideas and involving students in writing, drawing, concrete modeling, dramatizing and singing to develop their understanding and to perform their math learning. In North America, researchers also advocate creating opportunities for students to retell and extend stories and leading them to investigations of big math ideas (Gadanidis & Hughes, 2011; Murphy, 1999). Greenlaw and Tipps (1997) also point out that librarians, who are usually familiar with the materials in their collection, may play an important role. Mathematics teachers are encouraged to collaborate with librarians and also teachers in other fields to design and prepare valuable and interesting mathematics lessons using stories.

Both China's and North America's researchersstress the importance of encouraging students to create stories which can engage their interest while cultivating their creativity and ingenuity. However, during the process of using math stories, scholars in China emphasize integrating math stories into each phase of math teaching in order to establish an interesting scenario to motivate students' curiosity, passion and creative thinking. By contrast, researchers in North America pay more attention to developing hands-on activities and cross-curriculum activities to extend students' mathematical thinking. North America's scholars focus more on integrating math stories into class instruction than China's. Furthermore, some researchers in North America also focus on improving the quality of stories so that teachers can incorporate big math ideas and math

performance into a class to develop students' problem solving skills and the ability to reason and communicate mathematically, which is rarely mentioned in China.

2.2.4 What makes a good story?

Good math stories can be used to highlight mathematical concepts and act as a springboard to mathematics instruction. A good story that could attract students' attention must make sense and be fun. In North America, scholars put forward specific criteria for making a good math story from two aspects: physical and content characteristics. From the perspective of physical characteristics, several points are involved: "(1) color illustrations; (2) illustrations created through multiple mediums; (3) pages at least 8.5 by 11 inches; (4) text and an illustration on each page; (5) font large enough to read and blended with illustrations; (6) at least 12 pages of text excluding supportive pages; and (7) spiral bound on cardstock (no three-ring binders)" (Kurz & Bartholomew, 2012). The content of a good math story is expected to include the following elements: "(1) a problem-based mathematics task; (2) interesting, well-developed characters and plots; (3) helpful tools to solve the dilemma; (4) a plot that needs a dilemma solved using mathematics; and (5) original content (no sources)" (Kurz & Bartholomew, 2012; Martinez, J. R. & Mart ńez, N. C., 2000).

The research about the specific criteria for math stories in China is rather limited. Chinese research highlights that a good math story needs to have an interesting plot and characters (Zhong, 2010). Whether the math story integrates games, nursery rhyme, and riddles, whether the math story connects with mathematics textbooks, and whether the math story combines with comic books would be included as the specific criteria for choosing and designing a good math story (Chang, 2014).

2.3 Summary

The above literature review looks at the current mathematics education system in China and North America from three aspects: teaching and learning mathematics, the nature of mathematics and the learning environment. The literature review provides the context of the study, and relevant themes from the literature review will be identified and used in the data analysis stage.

According to the literature, the Chinese math education system is "test-oriented" which focuses more on the discipline of students' behavior and development of basic skills for the performance improvement; however, the math education system in North America is "quality-oriented" which emphasizes on the development of students' conceptual understanding of mathematics and the critical thinking.

From the review of existing studies above, we can see that in both China and North America there is some research about the application of math stories in elementary school. Storytelling is regarded as a significant pedagogy for mathematics instruction, especially in the elementary level. Scholars in both China and North America have researched the significance of using math stories to improve students' understanding of mathematics and the ability of mathematical thinking. Chinese scholars study more from the perspective of the integration of math stories into the process of a math class while North American scholars focus more on the cultivation of students' ability of problem solving and creativity thinking. Chinese studies of math stories are more limited, both in number and in terms of the development and variety of math stories in terms of plots and characters compared to the results of North America's research.

Though there are many studies about math stories in China and North America individually, studies from the comparative perspective of math stories in elementary school in China and North America are few, which shows the importance and necessity of this study, which aims to compare math stories themselves, as well as what makes a good math story in China and North America.

CHAPTER 3: THEORETICAL FRAMEWORK AND METHODOLOGY

This chapter introduces the theoretical framework and methodological approach of the study.

3.1 Theoretical Framework

The purpose of this study is to investigate the similarities and differences of math stories in China and North America. This research study is based on the constructivist theoretical perspectives of such theorists as John Dewey, Jean Piaget, and Lev Vygotsky. Various researchers in China and North America have investigated and theorized about the advantages and necessity of math stories for mathematics education in elementary school. Some researchers suggest that children's literature has the potential to help students better understand mathematics by building connections between complex mathematical concepts and the real world (Liu, 2014; Whitin, 1992). Others suggest that children's literature can help students improve problem solving skills and critical thinking (Murphy, 1999; Lou, 2011). The basis on which these researchers come to their conclusions is also based on the constructivism theory.

Constructivism is a theory of knowledge that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas (Piaget & Inhelder, 2008). Glasersfeld (1989) points out that, "knowledge is not passively received but actively built up by the cognizing subject" (p. 162). Current research on students' thinking and learning is largely consistent with constructivism. The following section summarizes the theoretical perspective that will guide the present study.

Dewey (2007) stated that quality education arises from active and reflective experiences. Under this condition, students are required to use what they already know and have experienced to construct new ideas into a meaningful way they can understand. When mathematical knowledge is connected with prior experiences, it results in deeper understandings. A new cognitive structure would be constructed when students assimilate the new concepts into the original knowledge during literature reading or learning. Vygotsky (1978) states that students can learn best if their learning experiences involve social interaction with peers and adults. Through interactions with others, students can examine, clarify and change their understandings. In this study, the comparison of math stories focuses on the combination of mathematics knowledge and children's literature to examine and compare the content and purpose of math stories. Whether the math stories could help students' increase their comprehension of the mathematics concepts and improve their mathematical thinking and problem solving skills are taken into consideration.

In summary, there are two key themes in constructivism, and both of them are used to frame this thesis: first, there is a focus on conceptual understanding, and second, there is a focus on students as active learners, which means students have to construct their own understanding. In this thesis, when comparing and analyzing Chinese math stories and North American ones, I discuss how they are different in the plot development and mathematical focus, and make judgments about their attention to conceptual mathematics understanding. I have noted that math stories are more conceptually rich in North American than in China, by for example giving students opportunities to see multiple presentations to make sense of ideas and develop robust conceptualizations. On the other

hand, I also make judgments about what makes for better Chinese stories and I add more representations, more dialogue, and more student involvement to one of the Chinese stories to show how conceptual understanding and students as active learners can be better illustrated in Chinese stories. All these judgments are made based on constructivism.

3.2 Methodology

In this study, data are collected by using the document analysis technique, which is a qualitative data collection method. Qualitative research methods are commonly used for providing in-depth and detailed description of procedures, beliefs, and knowledge (Labuschagne, 2003). Qualitative methods have the ability to identify intangible factors, such as social norms, historical culture, and gender roles. During qualitative research, using content analysis (Berg, 1998), patterns, categories and themes can be built by organizing the data into more abstract units of information (Braun & Clarke, 2006). Before the comprehensive sets of themes have been established, I work back and forth between the data and the themes. Then, themes are used to explore, classify and compare the topic of the research.

3.2.1 Research Questions

The study addresses the following research question: What are the similarities and differences of math stories in elementary mathematics education in China and North America? More specifically, I look at similarities and differences in themes of: physical characteristics, plot development, and mathematical focus.

3.2.2 Data Collection

Patton (2002) points out that qualitative findings stem from three kinds of data collection: “in-depth, open-ended interviews, direct observation, and written documents” (p. 4). According to Cohen, Manion and Morrison (2013), broad distinctions of documentary research are derived from the type of documents in which one of the distinctions can be made between primary documents and secondary documents. He proposes that primary documents are “a direct record of an event or process by a witness or subject involved in it” (p. 249). This study focuses completely on content analysis by using primary documents: math story books in China and North America.

To identify the stories to be used in this study, I gather fifty math stories for elementary students in China and in North America respectively according to recommendations from the professional researchers, authoritative academic papers, physical and online bookstores, and libraries in China and North America. Then, among these stories, the twenty most popular math stories for Grade One to Grade Six children from China and for North America are selected individually for math stories analysis. The popularity of math stories is defined according to three criteria: 1) How long has the story been around? The following Table 3.1 shows the year of first publication of the stories in China and North America. The twenty Chinese math stories are published from 2009 to 2014 which have been used for 3-8 years; the selected North American math stories are published from 1989 to 2009, and even though they are not written as recently as the ones from China, they are remaining popular.

Table 3. 1 Year of Math Stories’ Publication

Chinese Math Stories	**Year of first publication**	**North American Math Stories**	**Year of first publication**
How much is the volume of the Cylindrical Stone?; Grade 1-4	2009	*The Doorbell Rang;* Pre-Grade 3	1989
Back to HuaGuo Mountain; Grade 1-4	2009	*Counting on Frank;* Grade 4 and up	1991
Measuring the Height of Pyramid; Grade 1-4	2009	*Two of Everything;* K-Grade 3	1993
Outwit the Human Trafficker; Grade 1-4	2009	*Give Me Half*; Pre-Grade 2	1996
Ready for Fight; Grade 1-4	2009	*Stay in Line;* Pre-Grade 3	1996
Angel's Cup Lid; Grade 1	2010	*Grandfather Tang's Story;* Pre-Grade 2	1997
Drinking Cola; Grade 1	2010	*Lemonade For Sale;* Grade 2 and up	1997
Too Many People in the Supermarket; Grade 1	2010	*One Grain Of Rice: A Mathematical Folktale;* Pre-Grade 3	1997
Watermelon Cutting; Grade 2	2010	*Amanda Bean's Amazing Dream;* Pre-Grade 3	1998
Folding Carton; Grade 3	2010	*Jump, Kangaroo, Jump;*	1998

		Grade 2 and up	
How to Build a Fence; Grade 3	2010	*Anno's Magic Seeds;* Pre-Grade 3	1999
Red Bean Bun Sharing; Grade 3	2010	*A Remainder of One;* Pre-Grade 3	2002
The Chopsticks on the Table; Grade 3	2010	*A Place For Zero;* Grade 1-4	2003
Mutton Shashlik; Grade 4	2010	*Tally O'Malley;* Grade 1 and up	2004
Treating Guests; Grade 6	2010	*The Great Graph Contest; K-Grade 3*	2005
Gift Guessing; Pre-Grade 2	2014	*Sir Cumference and the Isle of Immeter;* Grade 1-7	2006
Christmas Party; Pre-Grade 2	2014	*It's Probably Penny;* K- Grade 3	2007
Save the Candy; Pre-Grade 2	2014	*Bean Thirteen;* Age 5-8, K-Grade 3	2007
Guess What You Think; Grade1-4	2014	*Spaghetti and Meatballs For All;* Grade 1-3	2008
Nectar of Bees; Grade 1-4	2014	*Mummy Math: An Adventure in Geometry;* Grade 2-5	2009

2) The rankings in Google searches are shown below in Table 3.2, using the key words “Children’s math stories.” According to Table 3.2, it can be seen that math stories

selected in this study are listed from the first four pages of Google searches and most of them are shown in the first page.

Table 3. 2 Google Result Page

Chinese Math Stories	Page of result	North American Math Stories	Page of result
Back to HuaGuo Mountain; Grade1-4	1	*The Doorbell Rang;* Pre-Grade3	1
How much is the volume of the Cylindrical Stone?; Grade 1-4	1	*Sir Cumference and the Isle of Immeter;* Grade 1-7	1
Measuring the Height of Pyramid; Grade 1-4	1	*A Remainder of One*; Pre-Grade 3	1
Outwit the Human Trafficker; Grade1-4	1	*One Grain Of Rice: A Mathematical Folktale*; Pre-Grade 3	1
Ready for Fight; Grade1-4	1	*Spaghetti and Meatballs For All*; Grade 1-3	1
Angel's Cup Lid; Grade 1	1	*Bean Thirteen*; Age 5-8, K-Grade 3	1
Drinking Cola; Grade *1*	1	*Tally O'malley*; Grade 1 and up	1
Too Many People in the Supermarket; Grade 1	1	*Give Me Half*; Pre-Grade 2	1
Watermelon Cutting; Grade 2	1	*Mummy Math: An Adventure*	1

		in Geometry; Grade 2-5	
Folding Carton; Grade 3	1	*Counting on Frank;* Grade 4 and up	1
How to Build a Fence; Grade 3	1	*Two of Everything;* K-Grade3	1
Red Bean Bun Sharing; Grade *3*	1	*A Place For Zero;* Grade 1-4	1
The Chopsticks on the Table; Grade 3	1	*Grandfather Tang's Story; Pre-Grade 2*	1
Mutton Shashlik; Grade 4	1	*Amanda Bean's Amazing Dream;* Pre-Grade3	1
Treating Guests; Grade 6	1	*Jump, Kangaroo, Jump;* Grade 2 and up	1
Gift Guessing; Pre-Grade Two	2	*Stay in Line;* Pre-Grade 3	1
Christmas Party; Pre-Grade Two	2	*Anno's Magic Seeds;* Pre-Grade 3	1
Save the Candy; Pre-Grade Two	2	*Lemonade For Sale;* Grade 2 and up	2
Mathematics Reading	3	*The Great Graph Contest; K-Grade 3*	3
Wonderful Math Magic	4	*It's Probably Penny;* K- Grade 3	3

3) Are the math stories used in school? Most of the selected Chinese math stories are recommended by famous Chinese primary school teachers, who are shown on the cover

of the story books, which also indicates that they are used in mathematics classrooms. For the selected North American math stories, most of them are recommended in academic and professional journal papers. This suggests that these North American math stories are used in schools.

By reviewing and analyzing math stories themselves, this study aims to explain the current situation of math stories in China and North America and to explore the similarities and differences of math stories in elementary mathematics education between China and North America.

3.2.3 Data Analysis

According to the collected math stories in elementary mathematics education in China and North America, this study does content analysis from the comparative perspective. Content analysis is defined as a "systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding" (as cited in Stemler, 2001, p. 1) According to Salminen, Kauppinen and Lehtovaara (1997), document analysis involves the analysis of written materials which refers to not only a method for document design but also an iterative process producing definitions for old documents structures. Therefore, I extract the important information from math story books related to the purpose of the study first. Then, I categorize the data into three themes: physical characteristics, plot development and mathematical development. Next, I summarize the information in each category and sort them with subcategories with reference to what makes a good story. Fourth, I go through each subcategory by generalizing the characteristics of the data or organizing the complex

information into tables. Fifth, the simplified data are reviewed and compared, and the results are listed.

This study uses document analysis from a comparative perspective to answer the question: what are the similarities and differences of math stories in elementary mathematics education in China and North America? The results of comparison are analyzed and discussed from the constructivist perspective. This study explores the similarities and differences between math stories from China and North America to provide implications for the creation and application of math stories in elementary mathematics education.

CHAPTER 4: FINDINGS

The purpose of this study is to present the situation of math stories in China and North America first, and then discuss the similarities and differences of math stories between China and North America with reference to relevant themes raised in the literature review in Chapter 2. This chapter describes the analysis of the data as organized according to the research question. It reports the findings beginning with physical characteristics of the stories, then plot development, and followed by mathematics focus in the story.

4.1 Physical Characteristics

Neumeyer (1979) and Martin (1996) point out that a good math story should consider whether the story fits the format, which includes the length of the content. In addition, Lacy (1986) and Shulevitz (1997) propose that story books for young children need to have enough pictures, which could help readers understand the story, and also to examine how the picture and text work together to form the whole. In addition, John Charles and Havir (1997) believe that publishers of story books should be aware of marketing capacity, such as the price of the book. Based on the existing studies about story books, this section compares math stories in China and North America from the perspective of the following physical characteristics: size, length, color, images and cost.

4.1.1 Size of math story books

Figures 4.1-4.4 represent what the common math story books look like in China and North America. Figure 4.1 and Figure 4.2 are Chinese math story books, and Figure 4.3 and Figure 4.4 are story books from North America. The dimensions of Figure 4.1-4.4 are 22.8x17x1.8 cm, 21.2x14.8x0.9 cm, 25.1x20.3x0.5 cm, and 22.9x15.2x0.8 cm

respectively. It can be seen that in both China and North America the length and width of math story books are similar. However, there exists a big difference in the thickness of math story books between China and North America. The Chinese math story books in Figure 4.1 and Figure 4.2 have 189 pages and 160 pages respectively, while North American story books from Figure 4.3 and Figure 4.4 have only 24 pages and 32 pages respectively. The number of Chinese math stories in Figure 4.1 is 80, and in Figure 4.2 is 49; however, North American math story books in Figure 4.3 and Figure 4.4 each contain only one math story. In summary, math story books from China and North America are nearly the same size; however, the number of pages of Chinese math story books is five to eight times that of the story books from North America.

Figure 4. 1 Example One (Chinese story): *Playing Math with Ma Xiaotiao*

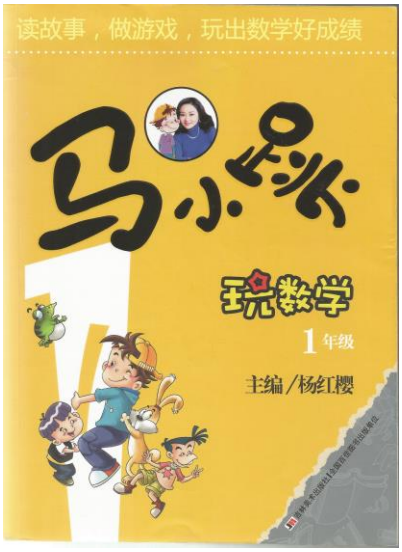


Figure 4. 2 Example Two (Chinese story): *Mathematics Journey to the West*

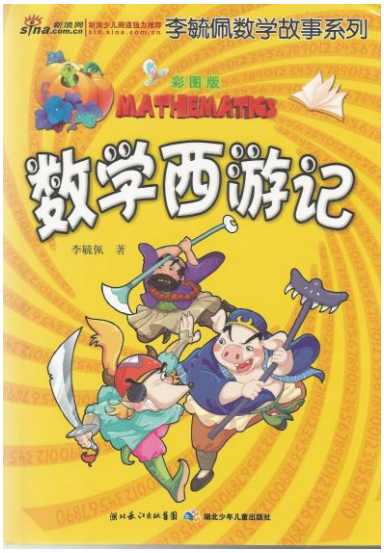


Figure 4. 3 Example One (North American story): *The Doorbell Rang*

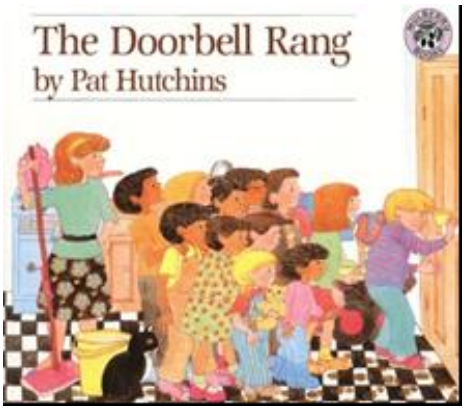
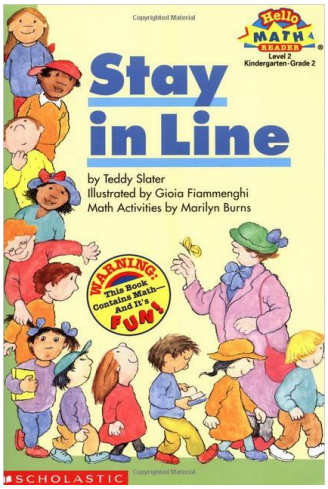


Figure 4. 4 Example Two (North American story): *Stay in Line*



4.1.2 Length of story

Most of the math stories in China are two pages long, such as the one shown in Figure 4.5. At the same time, however, there are still some math stories which are four to eight pages or even more pages long, such as the one shown in Figure 4.6 which is four pages long. In North America, most of the math stories are about twenty to thirty pages long. However, math stories in North America are generally two to four lines of words on each page (see Figure 4.7 and Figure 4.8) while Chinese math stories have approximately ten to twenty lines of text on each page (see Figure 4.5 and Figure 4.6). If we focus only on the text (and ignore number of pages) it can be concluded that the length of math stories in China and North America are approximately the same.

4.1.3 Color

Figures 4.5 4.6 are two representative math stories in China which are suitable for students in Grade one to three. Figures 4.7 and 4.8 are typical math stories in North America and they are designed for students from Preschool to Grade Three and Kindergarten to Grade Two respectively. My interest focuses on the level from Grade One to Grade Six. Some math stories in China (Figure 4.5) use black and one other color in their illustrations, while other math stories in China (Figure 4.6) use the full color spectrum. On the other hand, stories in North America (Figure 4.7 and Figures 4.8) typically use the full color spectrum in their illustrations.

4.1.4 Size of text

The font of Chinese stories from Figure 4.5 and Figure 4.6 are 14 pt. KaiTi font and 12 pt. SimSun font; while both the text in Figure 4.7 and Figure 4.8 use 12 pt. Times New Roman font. In short, the text of math stories from China and North America use

different character with different font. Although some of the Chinese math stories use a slightly larger size of text than North American ones, most of the math stories in both China and North America use approximately the same size of text.

Figure 4. 5 Example One (Chinese story): Size of Text & Text and Images

Figure 4. 6 Example Two (Chinese story): Size of Text & Text and Images

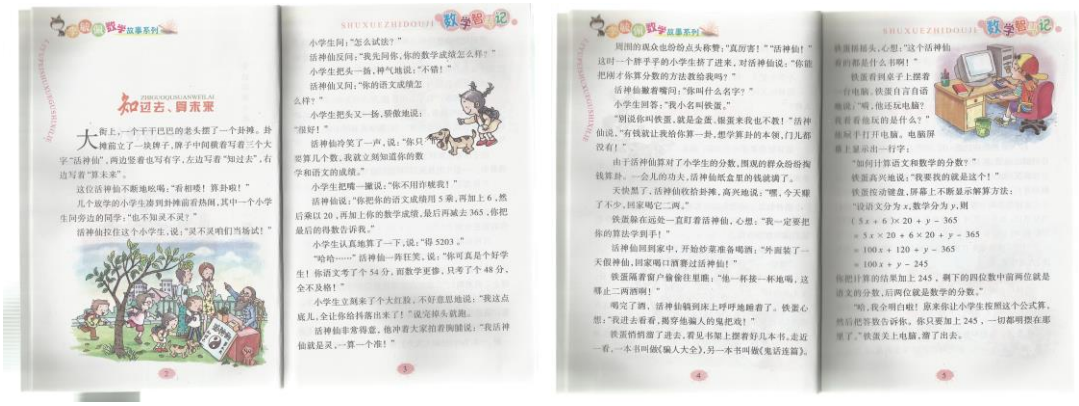
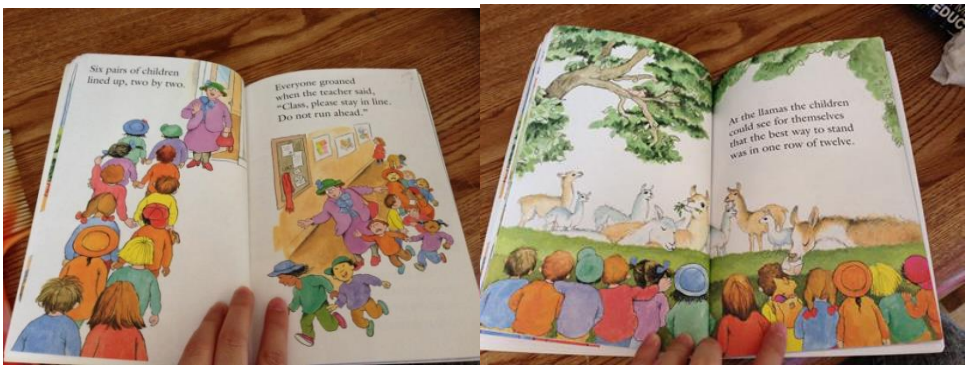


Figure 4. 7 Example One (North American story): Size of Text & Text and Images

Figure 4. 8 Example Two (North American story): Size of Text & Text and Images



4.1.5 Text and images

A common element in Chinese and North American math stories is the combination of pictures and text, as depicted in Figures 4.5-4.8. However, the pictures in the Chinese math stories are on the side, as in the two shown in Figure 4.5 and Figure 4.6,while the pictures in North American stories are prominently centered, as can be seen from Figure 4.7 and Figure 4.8. In general, math stories in China and North America use completely different ways to insert the pictures into the text. Furthermore, another key difference is that the proportion of text to images is much greater in math stories from China than in North America. This is evident in Figures 4.5-4.6 from China and Figures 4.7-4.8 from North America. In Figure 4.5 we see that there are fifteen lines of text with one picture on

the first page and thirteen lines of text on the second page. In Figure 4.6 there are eight lines of text with one picture on the first page and twenty-two lines of text with one picture on the second page. In contrast, we see that Figures 4.7 and 4.8 each contain two to four lines of text with one picture. Although math stories in both China and North America have integrated pictures with text, it is significant that the proportion of pictures to text in North American math stories is higher than that in China.

In addition, in North American math stories the meaning of text fully matches with the picture, as shown from Figure 4.7 and Figure 4.8. However, in Chinese math stories only some of the ideas of the texts are illustrated by the pictures. Here is the translation of each paragraph of the math story from the first page of Figure 4.5 from China.

Paragraph one: "One day, Ma Xiaotiao's house was full of excitement because her mother invited some friends to their home. Ma Xiaotiao counted the shoes beside the door and the total number is 12 pair of shoes."

Paragraph two: "Before the dinner, Ma Xiaotiao's Mom asked him to go to the supermarket to buy some drinks with her. Xiaotiao was so happy to accompany with her Mom because he wanted to buy some coke. He loves cola so much."

Paragraph three: "There were many different kinds of drinks in the supermarket and Xiaotiao's Mom asked him that what kind of drink he wants to buy. However, Xiaotiao focused on finding the cola and didn't hear what his Mom was saying."

The picture in the first page of Figure 4.5 appears related to paragraphs two and three, but it is actually best matched to the text on the next page, where Mom and

Xiaotiao discuss how much ice tea they need to buy, given the discount "buy three, get one free", which is translated as follows:

Paragraph four: Ma Xiaotiao's Mom finally stopped in front of the ice tea, and said, "Shall we buy ice tea?" Xiaotiao was not very happy and said, "I want to drink cola." At this time, his Mom said, "The advertisement shows: buy three, get one free. Great deal! And it is not healthy to always drink cola." Xiaotiao's Mom put the ice tea into the shopping cart while talking to him. Xiaotiao has no choice but to help his Mom.

Paragraph five: "Enough! We only need to buy 9 bottles ice tea." Xiaotiao's Mom said when she saw Xiaotiao bringing another bottle of ice tea to the cart. Xiaotiao said, "I have counted there are 12 people in our home." His Mom reminded him that if we buy three, we will get one free, so we need to buy only 9 bottles. Xiaotiao suddenly understood with a pat-on-the-head.

At this point, it is evident that the picture in the first page of Figure 4.5 best matches with the last paragraph of this story, which is on the second page. The collocation of texts and pictures in Figure 4.6 is similar to the situation in Figure 4.5. In North America math stories, each page's picture illustrates the ideas of the text on this page. However, pictures on each page of Chinese math stories generally only illustrates a part of the story.

If this story were written in North America, each of paragraphs would likely have a picture. For example, paragraph one provides an important information that teachers would pose a question in the class, "how many people are there in Xiaotiao's home?" Thus, there would an image shows the 12 pair of shoes at the door with paragraph one in

North America. In paragraph two, Xiaotiao wants to buy coke, in which teachers would ask whether it is healthy for children to drink coke. Therefore, a picture showing the coke and orange juice on the shelf would be provided for this paragraph. Paragraph four presents the key information: “buy three, get one free.” For a North America math stories, an image showing three lines of three cokes and one different drink on the shelf would match with this paragraph.

4.1.6 Cost

Table 4.1 and Table 4.2 present the average price of five typical Chinese and North American math stories books separately. The average cost of Chinese math story books in Table 4.1 is $2.32, while the average price of books from North America is $6.57, as shown in Table 4.2. According to Tables 4.1-4.2, it can be seen that the price of math story books from North America is almost three times as much as those from China (not considering the income of citizens from the two nations). However, on the basis of World Bank’s most recent data, China’s GDP per capita from 2011-2015 was $7590.0, whereas the United States and Canada’s GDP per capita during 2011-2015 were $54629.5 and $50235.4 respectively. Table 4.3 shows the ratio of the price of math story books accounted for GDP per capita from two nations, where the average GDP per capita in United States and Canada is taken as the GDP per capita of North America. The ratio of China is 0.0306% and the ratio of North America 0.0125%, which explains that the price of Chinese math story books is more expensive for Chinese citizens, compared to the situation of North America in a relative way.

Table 4. 1 The Price of Chinese Math Story Books

Chinese Math Stories	Price
Playing Math with Ma Xiaotiao	￥19.8 ≈ $3.04
Mathematics Journey to the West	￥14.8 ≈ $2.27
My Favorite Math Story Book	￥12.8 ≈ $1.97
Mathematics Reading	￥10 ≈ $1.54
Wonderful Math Magic	￥18 ≈ $2.77
The Average Price	**￥15.1 ≈ $2.32**

Table 4. 2 The Price of North American Math Story Books

North American Math Stories	Price
Anno's Magic Seeds	$7.99
Grandfather Tang's Story	$7.99
The Doorbell Rang	$5.95
Sir Cumference and the First Round Table	$6.95
Stay in Line	$3.99
The Average Price	**$6.57**

Table 4. 3 The Ratio of Price/GDP per capita

Country	GDP per capita	Price	Ratio

China		$7590.0	$2.32	0.0306%
North America	U.S.	$54629.5	$6.57	0.0120%
	Canada	$50235.4		0.0131%
	Average	$52432.45		0.0125%

NOTE:

1. The data of GDP per capita comes from the World Bank's website: http://data.worldbank.org/indicator/NY.GDP.PCAP.CD

2. Price represents the cost of math story books in China and North America, and the data come from Table 4.1 and Table 4.2.

3. Ratio equals to the Price/GDP per capita.

Table 4. 4 Similarities and Differences of Math Stories in Physical Characteristics

	Chinese Math Stories	**North American Math Stories**
Similarities	▫ The length of math stories (only focusing on the text of the math stories). ▫ The font size of the text of the math stories.	
Differences	▫ One story book has more than 150 pages. (One book, more than 40 stories) ▫ Some stories use full color spectra, the others use two colors. ▫ Pictures in the stories are on the side. ▫ 10-20 lines of text with one picture. ▫ Pictures on each page can illustrate part of story. ▫ The cost of books/GDP per capital is 0.0306%.	▫ One story book has 20-40 pages. (One book, one story) ▫ All the stories use the full color spectrum in the images. ▫ Pictures in the stories are centered. ▫ 2-4 lines of text with one picture. ▫ The meaning of texts matches with the picture on each page. ▫ The cost of books/GDP per capital is 0.0125%.

As summarized in Table 4.4, there are more differences than similarities in Physical Characteristics between Chinese and North American math stories. The similarities are

shown in two aspects: the length and font size of the text of math stories. However, the differences manifest in six ways: 1) One single Chinese math story book has five to eight times the number of pages that a single North American book contains; 2) All the math stories in North America use the full color spectrum in the images, while some Chinese math stories only use black and one other color; 3) Pictures in Chinese math stories are on the side while in North American stories are centered; 4) The ratio of images to text in North American math stories is higher than that of Chinese math stories; 5) The meaning of the text matches with the picture on each page in North American math stories, however, the pictures in Chinese math stories only illustrate part of the text; 6) When taking into account income, Chinese math story books are more expensive for Chinese citizens than North American stories for North American citizens.

4.2 Plot development

Abrahamson and Shannon (1983), Lebowitz (1984), Tarlow (1998), and Bicknell and Trotman (2000) point out the importance of the plot for a story book and propose that a well-developed plot with solid and close to life characters and setting is essential for a good children's literature creation. This study also deals with the role of posing and solving problems based on the research purpose. Therefore, in this section, I compare plot development of math stories in China and North America from the following aspects: setting, characters, and the characters' roles in posing/solving problems.

4.2.1 Setting

Table 4.5 presents the setting of each math story from China and North America separately. Of the 20 Chinese math stories on the left side of Table 4.5, three of them happened at school, nine occurred at home and the rest took place in other settings: the

supermarket (3), forest (2), tourist attraction (1), park (1), and fictional scenes (4). Of the 20 math stories from North America, on the right side of Table 4.5, one of them happened at school, nine stories occurred at home and some other stories occurred in other settings: the zoo (1), market (1), vocation resort (2), and some fictional scenes (7).

According to Table 4.5, it can be seen that both China and North America have nine (or 45%) math stories taking place at home, and also have some math stories happening in some fictional scenes. Few math stories in China and North America choose school as the location. Three of the Chinese math stories took place at school while only one of the North American did so. What's more, all the three Chinese math stories happened after class at school, such as during the class break, after school in the classroom, and in the community room. However, the North American math story took place in a math class first and then at home.

In both China and North America, most math stories set the scene of the story at home and they also prefer to use places related to children's lives, like a zoo, park, and forest and create some fictional places. A key difference is that some North American math stories involve a child's dream or imagination, which does not appear in Chinese stories.

Table 4. 5 The Location of Math Stories in China and North America

Chinese Math Stories	**Location**	**North American Math Stories**	**Location**
Angel's Cup Lid; Grade 1	During class break period at school	*It's Probably Penny;* K- Grade 3	At school and home

Folding Carton; Grade 3	After school in the classroom	*Bean Thirteen;* Age 5-8, K-Grade 3	At home
Christmas Party; Pre-Grade Two	At school and home	*Give Me Half; Pre-Grade 2*	At home
How to Build a Fence; Grade 3	At home	*The Doorbell Rang;* Pre-Grade 3	At home
Red Bean Bun Sharing; Grade 3	At home	*Two of Everything;* K-Grade 3	At home
Mutton Shashlik; Grade 4	On the way home	*Spaghetti and Meatballs For All;* Grade 1-3	At home
The Chopsticks on the Table; Grade 3	In the dining room	*Anno's Magic Seeds;* Pre-Grade 3	Somewhere Jack lived
Watermelon Cutting; Grade 2	At Xiaotiao's home	*The Great Graph Contest;* K-Grade 3	At Honk's home and outside
How much is the volume of the Cylindrical Stone?; Grade 1-4	In the yard	*Grandfather Tang's Story; Pre-Grade 2*	In the backyard
Too Many People in the Supermarket; Grade 1	In the supermarket and at home	*Stay in Line;* Pre-Grade 3	In the Zoo

Treating Guests; Grade 6	In the supermarket and at home	*Lemonade For Sale;* Grade 2 and up	In the market
Drinking Cola; Grade 1	In the supermarket	*Tally O'malley;* Grade 1 and up	On the way to Vocation
Save the Candy; Pre-Grade Two	In the forest	*Mummy Math: An Adventure in Geometry;* Grade 2-5	In Egypt
Outwit the Human Trafficker; Grade1-4	In the forest	*A Place For Zero;* Grade 1-4	In the Digit Kingdom
Measuring the Height of Pyramid; Grade 1-4	In Egypt	*Amanda Bean's Amazing Dream;* Pre-Grade 3	In Amanda's dream
Gift Guessing; Pre-Grade Two	At the amusement park	*A Remainder of One;* Pre-Grade 3	In the Bug Kingdom
Guess What You Think; Grade 1-4	On a festival celebration activity	*Counting on Frank;* Grade 4 and up	At home in the son's mind
Back to HuaGuo Mountain; Grade 1-4	At Huaguo Mountain	*Jump, Kangaroo, Jump;* Grade 2 and up	In a sports event on Field Day
Nectar of Bees; Grade 1-4	In the Bee's house	*One Grain Of Rice: A*	At the Palace

		Mathematical Folktale; Pre-Grade 3	
Ready for Fight; Grade 1-4	In the animal's army	*Sir Cumference and the Isle of Immeter;* Grade 1-7	On an island

4.2.2 Characters

Tables 4.6 and 4.7 summarize information about the characters from 20 Chinese and 20 North American math stories. From the perspective of Role and Relationship of Characters, Table 4.6 shows that six Chinese stories' main characters are anthropomorphic animals and the other stories' lead characters are all young children. It is similar in North America (see Table 4.7) that the main characters in eight math stories are animals; however, the lead characters in other stories are not only children, but also old men and couples. From the age of characters, apart from the fictional characters like animals, both Chinese and North American math stories have young children as lead characters; however, North American math stories have adults as lead characters as well.

The relationships of characters in twelve Chinese math stories are friends/classmates, in six stories are families, such as parents, grandparents, and cousins, in one story it is a monarch and subject, like King and Commander, and in another one it is a stranger. It is similar in North America: characters in six stories are friends/classmates, in eleven stories are families, including parents, twins, and sons and daughters, and in three stories are monarch and subjects. The difference is that strangers

as characters are not common in North American math stories. All the characters in North American stories are familiar with one another, while some characters in Chinese stories have never met before. To put it in another way, the relationship of characters in Chinese math stories can also be categorized into three types. The first kind is that the characters are all humans or fictional characters who know each other, for example, in *Watermelon Cutting*, characters are primary school students and they are friends. The second kind of characters is humans and fictional characters coming from other literatures so that humans are familiar with the fictional characters. For example, in Chinese story *How much is the volume of the Cylindrical Stone,* the main character Sun Wukong is a fictional character in one Chinese masterpiece called "A *Journey to the West*," and the other young character Xiaoniu knows Sun Wukong through the book before. And this story starts from the situation that a real Sun Wukong appears in front of Xiaoniu one day. Another type of character involves strangers, who never know or meet each other before, such as the characters in *Measuring the Height of Pyramid* who meet in front of the Pyramid for the first time. The first two kinds of relationships can also be seen in North American math stories, but not the third one.

The number of characters in both Chinese and North American math stories is more than two, usually in the range of two to five, and a few stories also include more than ten characters. Although many characters are mentioned in one story, mostly only one to three characters play an important role in the plot development, which is the same in China and North America. Among the characters in 20 Chinese math stories, the number of male roles accounted for 73% and female takes up 27%. In the 20 North American math stories, the number of male roles accounted for 55% while females occupy 45%.

According to the Table 4.6 and Table 4.7, it can be found that there are more males in math stories than females in both China and North America; however, the proportion of male to female characters in North American math stories is more balanced than in Chinese stories.

Table 4. 6 The Role and Relationship and the Gender of Characters in Chinese Stories

Chinese Math Stories	**Role and Relationship of Characters**	**Gender**	
		Male	**Female**
Christmas Party; Pre-Grade Two	Mo Ersi, his dad, his teacher, his six classmates-three girls and three boys.	6	3
Measuring the Height of Pyramid; Grade 1-4	Xiao Yanjing, an old man, Tai Lesi, and a business man.	4	0
Watermelon Cutting; Grade 2	Xiaotiao and his friends Mao Chao, Zhang Da and Tang Fei.	4	0
Mutton Shashlik; Grade 4	Tang Fei, his friends Zhang Da, Xiaotiao and Xiaotiao's desk mate, a girl Manman.	3	1
Folding Carton; Grade 3	Xiaotiao, his grandfather and his dad.	3	0
Outwit the Human Trafficker; Grade 1-4	Human Trafficker Qiankui, and two little kids, Heidan and Mingming.	3	0

Gift Guessing; Pre-Grade Two	Xi Meng, and his friends, two girls Ge Leisi and Zhan Ni, and an odd man.	2	2
Treating Guests; Grade 6	Xiaotiao, his mom and dad.	2	1
Angel's Cup Lid; Grade 1	Little kid Angel, and her classmates Mao Chao and Xiaotiao.	2	1
Red Bean Bun Sharing; Grade *3*	Xiaotiao and his friends Chao.	2	0
The Chopsticks on the Table; Grade 3	Xiaotiao and his brother Xiaozhou.	2	0
Too Many People in the Supermarket; Grade 1	Little kid Angel and her mom and dad.	1	2
Drinking Cola; Grade *1*	Little kid Xiaotiao and his mom.	1	1
How to Build a Fence; Grade 3	Huang Ju, and her classmate Angel.	0	2
Guess What You Think; Grade1-4	A little Wise Goat Duoduo and a little Squirrel Qiqi.	N/A	N/A
Nectar of Bees; Grade 1-4	Burt's Bee and its grandfather, and two leaders.	N/A	N/A

Save the Candy; Pre-Grade Two	Little kid Momo, a bad wizard, helpful little dear Banban, woodchuck, and his mom.	N/A	N/A
Back to HuaGuo Mountain; Grade 1-4	Monkey King Sun Wukong, his brother Zhu Bajie, a math monkey, and a wolf.	N/A	N/A
Ready for Fight; Grade 1-4	Commander cow Niuniu, his officer rabbit Xiaoqi and the King.	N/A	N/A
How much is the volume of the Cylindrical Stone?; Grade 1-4	Little kid Xiaoniu and Sun Wukong.	N/A	N/A

NOTE: If the characters are animals or animals and people talk with each other, the gender cell will be marked N/A.

Table 4. 7 The Role and Relationship and the Gender of Characters in North American Stories

North American Math Stories	**Role and Relationship of Characters**	**Gender**	
		Male	**Female**
Spaghetti and Meatballs For All; Grade 1-3	Mr. Comfort and Ms. Comfort, and their thirty relatives and neighbors.	16	16
The Doorbell Rang; Pre-Grade3	Victoria and Sam, their Ma and Grandma, and ten guests.	9	3
Stay in Line; Pre-Grade 3	Twelve boys and girls classmates and a teacher.	7	6

Lemonade For Sale; Grade 2 and up	Members of Elm Street Kid's Club, Meg, Matthew, Danny, Sheri, and newer Jed and a pet parrot	4	1
Tally O'malley; Grade 1 and up	Brother Eric, sister Bridget and little Nell, and their mom and dad.	2	3
One Grain Of Rice: A Mathematical Folktale; Pre-Grade 3	Raja, Minister, Servant, and clever girl Rani.	2	2
Anno's Magic Seeds; Pre-Grade 3	Jack, kind Wizard, his wife Alice.	2	1
Counting on Frank; Grade 4 and up	Little kid and his father and mother.	2	1
It's Probably Penny; K-Grade 3	Lisa, her teacher Mr. Jayson, her friend Rosa, and her pet Penny.	2	1
Give Me Half; Pre-Grade 2	Sister, Brother and Mom.	1	2
Two of Everything; K-Grade 3	Mr. Haktak and Mrs. Haktak.	1	1
Mummy Math: An Adventure in Geometry; Grade 2-5	Matt, and his twin sister Bibi, and their dog.	1	1
A Place For Zero; Grade	Zero, King Multiply, Queen	N/A	N/A

1-4	Addeleine, Minister Count Infinity.		
Amanda Bean's Amazing Dream; Pre-Grade 3	Little kid Amanda, Sheep, Grandma, Mother, and Teacher.	N/A	N/A
A Remainder of One; Pre-Grade3	Joe, Queen, bad Sergeant Steven Mosquito, helpful Honeybee and Dragonfly.	N/A	N/A
Bean Thirteen; Age 5-8, K-Grade 3	Insects Ralph and Flora, and their friends April, Joe, Meg, Rocco.	N/A	N/A
Jump, Kangaroo, Jump; Grade 2 and up	Kangaroo counselor Ruby, and twelve animals.	N/A	N/A
Sir Cumference and the Isle of Immeter; Grade 1-7	Per, his cousin Radius, Uncle Sir Cumference, Aunt lady Di of Ameter, and a sea serpent.	N/A	N/A
Grandfather Tang's Story; Pre-Grade 2	Grandfather Tang, little Soo, two foxes Chou and Wu Ling, and a hunter.	N/A	N/A
The Great Graph Contest; K-Grade 3	Insects Gonk, Beezy and Chester.	N/A	N/A

NOTE: If the characters are animals or animals and people talk with each other, the gender cell will be marked N/A.

4.2.3 Characters' roles in posing/solving problems

This section looks at all of the 20 Chinese and 20 North American stories from the following aspects: who posed the problem, who solved the problem, and does anyone help?

Table 4.8 and Table 4.9 present the characters' roles in posing/solving problems in 20 Chinese and 20 North American math stories. Across the 20 Chinese math stories, twenty-three mathematical problems are posed (see Table 4.8), among which seven problems are raised by Children, five problems are proposed by Parents/Grandparents, one problem is posed by a Teacher, and the others (9) are presented by Fictional Characters. Except for one story that didn't present solutions, but asked readers to find the answers, twenty-two problems are solved, among which fourteen problems are solved by Children, the rest are solved by a wise man (1), and Fictional Characters (7). Table 4.9 shows that no problems are mentioned in eight North American math stories. Although some math stories in North America pose more than two problems in a single story, the problems are raised by the same character in each. Of the other twelve stories in North America, two problems are posed by Children, one problem is raised by Parents, two problems are presented by Teachers, and the other problems are proposed by Guests (1), the Author (1), and Fictional Characters (5). Table 4.9 shows that seven mathematical problems are solved by Children, and the others include a Couple (1), the Author (1), and Fictional Characters (3). Considering the characters' roles in posing problems, both Chinese and North American math stories use characters that are Children, Parents, Teachers, and Fictional Characters. However, North American math stories also use Guests and the Author. For the characters who solves the problem(s), both math stories in

China and North America use Children characters the most, and also Fictional Characters. Furthermore, North American math stories also use a Couple and the Author, while only Chinese math stories make use of a wise man. Besides the Fictional Characters, both Chinese and North American stories have more Children characters than others in posing and solving problems. However, the characters' roles offer more variety in North American stories than that in Chinese stories.

In terms of the category "Does anyone help," Table 4.8 shows that characters in five Chinese math stories solve the problems with the help of others, which include parents, classmates, and friends. However, all the characters in North American stories solve the problems independently.

According to the Table 4.8 and Table 4.9, both Chinese and North American math stories use a variety of character roles and the largest number of characters involved in posing and solving problems in China and North America are children; however, it can also be seen that the roles in North American math stories offer more diversity than in China. Another key difference is that none of the characters in North American math stories solve the problems with the help of others, while some characters in Chinese math stories do.

Table 4. 8 Character Roles in Posing/Solving Problems in Chinese Math Stories

Chinese Math Stories	Who Poses the Problem	Who Solves the Problem	Does Anyone Help
Drinking Cola; Grade 1	Xiaotiao's Mom	Xiaotiao	His mom reminds him

			that “buy three, get one free.”
Treating Guests; Grade 6	Xiaotiao’s Dad	XIaotiao	Xiaotiao’s Dad asks “why not only buy cans of cola.”
Christmas Party; Pre-Grade Two	Mo Ersi’s teacher asks him to be in charge of the preparation.	Mo Ersi	Mo Ersi’s father advises him to build a table and his classmates offer some suggestions.
Back to HuaGuo Mountain; Grade 1-4	First problem: Sun Wukong; Second problem: Zhu Bajie	The math monkey and Zhu Bajie	Zhu Bajie asks 14 monkeys to leave and the math monkey tells him it’s 13, not 14.
Ready for Fight; Grade 1-4	Officer rabbit Xiaoqi	Officer rabbit Xiaoqi	Commander cow Niuniu advises Xiaoqi to let the left three soldiers be flag guards.
How much is the volume of the	Sun Wukong	Xiaoniu	No

Cylindrical Stone?; Grade 1-4			
Angel's Cup Lid; Grade 1	Xiaotiao and Chao	Xiaotiao	No
Folding Carton; Grade 3	Huang Ju	Angel	No
Mutton Shashlik; Grade 4	Fei	Lu Manman	No
Outwit the Human Trafficker; Grade 1-4	Hei Dan	Hei Dan	No
Red Bean Bun Sharing; Grade *3*	Xiaotiao invited friends to his home, and they all hungry at noon.	Xiaotiao	No
The Chopsticks on the Table; Grade 3	Xiao Feizhou	Xiao Feizhou and Xiaotiao	No
Too Many People in the Supermarket; Grade 1	Angel's Dad	Angel gives a wrong answer.	No
How to Build a Fence; Grade 3	Xiaotiao's Grandfather	Xiaotiao	No

Gift Guessing; Pre-Grade Two	The park	Zhan Ni and Xi Meng	No
Measuring the Height of Pyramid; Grade 1-4	The pharaoh of Egypt	Tai Lesi	No
Guess What You Think; Grade 1-4	A little Wise Goat Duoduo	A little Wise Goat Duoduo	No
Nectar of Bees; Grade 1-4	Burt's Bee's grandfather	Burt's Bee	No
Save the Candy; Pre-Grade 2	First problem: The bad wizard; Second problem: Momo's mother; Third problem: Benben	First problem: Little dear Banban, woodchuck Benben; Second problem: Momo; Third problem: Banban	No
Watermelon Cutting; Grade 2	Xiaotiao	No one answered the question in the story, and the answer is given at the end of the story.	N/A

NOTE: If the problem is not solved in the story, the "does anyone help" cell will be marked N/A.

Table 4. 9 Character Roles in Posing/Solving Problems in North American Stories

North American Math Stories	Who Pose the Problem	Who Solve the Problem	Does Anyone Help
Counting on Frank; Grade 4 and up	The boy	The boy	No
Lemonade For Sale; Grade 2 and up	Danny	Sheri	No
The Doorbell Rang; Pre-Grade 3	Mom	The kids	No
Amanda Bean's Amazing Dream; Pre-Grade 3	Amanda's teacher	Amanda	No
It's Probably Penny; K-Grade 3	The teacher	Lisa	No
Spaghetti and Meatballs For All; Grade 1-3	The guests	Ms. Comfort	No
Anno's Magic Seeds; Pre-Grade 3	The author	The author	No
A Remainder of One; Pre-Grade 3	The queen of the bugs	Private Joe	No

A Place For Zero; Grade 1-4	Zero	Zero, Count infinity, King Multiply	No
Bean Thirteen; K-Grade 3	Ralph	Ralph and Flora	No
Sir Cumference and the Isle of Immeter; Grade 1-7	Secret of Immeter	Young girl Per and her cousin Radius	No
Mummy Math: An Adventure in Geometry; Grade 2-5	The mystery of the tomb	Matt and Bibi	No
Give Me Half; Pre-Grade 2	N/A	N/A	N/A
Jump, Kangaroo, Jump; Grade 2 and up	N/A	N/A	N/A
Stay in Line; Pre-Grade 3	N/A	N/A	N/A
Tally O'Malley; Grade 1 and up	N/A	N/A	N/A
Two of Everything; K-	N/A	N/A	N/A

Grade 3			
One Grain Of Rice: A Mathematical Folktale; Pre-Grade 3	N/A	N/A	N/A
Grandfather Tang's Story; Pre-Grade 2	N/A	N/A	N/A
The Great Graph Contest; K-Grade 3	N/A	N/A	N/A

NOTE: If the story does not propose problems, the "who pose the problem," "who solve the problem," and "does anyone help" cells will be marked N/A.

4.3 Mathematical Focus

Martin (1996) suggests that when writing a children's story book, the text should be organized with themes which might help readers learn from the book. In addition, more and more studies explore the integration of math concepts and children's literature to stimulate mathematics learning and improve the quality of illustration (Thatcher, 2001; Whitin, 1992). In this section, I compare the mathematical focus of math stories from the perspective of mathematical strands, how mathematical problems are solved and pedagogical development.

4.3.1 Mathematical strands

The Chinese Mathematics Curriculum has four areas of mathematical knowledge and skills in each grade: Number and Algebra, Graphics and Geometry, Statistics and Probability, and Comprehension and Practice. In North America, specifically in Ontario, Canada, the areas of mathematics knowledge and skills are: Number Sense and Numeration, Measurement, Geometry and Spatial Sense, Pattering and Algebra, and Data Management and Probability. The areas of mathematics study in both China and North America cover Number, Algebra, Geometry and Statistics/Probability. Their differences are that the Chinese curriculum does not list Measurement separately (it covers it under the topic of Graphics and Geometry) and it includes a distinct focus on Practice (it stresses the application of mathematical knowledge and skills, including designing and participating in a practical activity with a group, learning through proposing, analyzing, and solving problems under an actual situation). In this section, for the purpose of comparison, both Chinese and North American math stories are categorized according to the classification of Ontario's mathematical strands.

As can be seen from Table 4.10, twenty stories each were selected from China and North America. Nine Chinese math stories and ten North American stories focus on Number Sense and Numeration; five Chinese math stories and seven North America math stories describe Pattering and Algebra; two Chinese math stories and three North American stories are related with Measurement; four Chinese math stories contain Geometry and Spatial Sense and North America has two; in the area of Data Management and Probability, China and North America have two and three math stories respectively. The number of math stories in each strand is similar in China and North America. In both

China and North America, approximately one-half of the math stories are related to Number Sense and Numeration. Some math stories in both China and North America focus on more than one strand, such as *Treating Guests* and *Guess What You Think* in China, and *A Remainder of One* and *The Doorbell Rang* in North America.

Table 4. 10 The Classification of Math Stories by Mathematical Strands

Mathematical Strand	Chinese Math Stories	North American Math Stories
Number Sense and Numeration	*Angel's Cup Lid;* Grade 1 *Too Many People in the Supermarket;* Grade 1 *Drinking Cola;* Grade 1 *Guess What You Think;* Grade 1-4 *Nectar of Bees;* Grade 1-4 *Save the Candy;* Pre-Grade 2 *Red Bean Bun Sharing;* Grade 3 *Mutton Shashlik;* Grade 4 *Treating Guests;* Grade 6	*Bean Thirteen;* K-Grade 3 *Two of Everything;* K-Grade 3 *Give Me Half;* Pre-Grade 2 *Amanda Bean's Amazing Dream;* Pre-Grade 3 *A Remainder of One;* Pre-Grade 3 *The Doorbell Rang;* Pre-Grade 3 *Stay in Line;* Pre-Grade 3 *A Place For Zero;* Grade 1-4 *Tally O'Malley;* Grade 1 and up *Jump, Kangaroo, Jump;* Grade 2 and up

Pattering and Algebra	*Gift Guessing;* Pre-Grade 2 *Back to HuaGuo Mountain;* Grade 1-4 *Guess What You Think;* Grade 1-4 *Ready for Fight;* Grade 1-4 *Treating Guests;* Grade 6	*Bean Thirteen;* K-Grade 3 *Anno's Magic Seeds;* Pre-Grade 3 *A Remainder of One;* Pre-Grade 3 *One Grain Of Rice: A Mathematical Folktal;* Pre-Grade 3 *Stay in Line;* Pre-Grade 3 *The Doorbell Rang;* Pre-Grade 3 *Spaghetti and Meatballs For All;* Grade 1-3
Measurement	*How much is the volume of the Cylindrical Stone?;* Grade 1-4 *Measuring the Height of Pyramid;* Grade 1-4	*Spaghetti and Meatballs For All;* Grade 1-3 *Sir Cumference and the Isle of Immeter;* Grade 1-7 *Counting on Frank;* Grade 4 and up
Geometry and Spatial Sense	*Watermelon Cutting;* Grade 2 *Folding Carton;* Grade 3 *How to Build a Fence;* Grade 3 *The Chopsticks on the Table;*	*Grandfather Tang's Story;* Pre-Grade 2 *Mummy Math: An Adventure in Geometry;* Grade 2-5

	Grade 3	
Data Management and Probability	*Christmas Party;* Pre-Grade 2 *Outwit the Human Trafficker;* Grade 1-4	*It's Probably Penny;* K-Grade 3 *The Great Graph Contest; K-Grade 3* *Lemonade For Sale;* Grade 2 and up

NOTE: These twenty Chinese math stories are selected from story books *Playing Math with Ma Xioatiao* series by the author Yang Hongying*; Mathematics Journey to the West*, *The Commander of Mathematics*, and *the Small Glasses of Mathematics* by the author Li Yupei; *My Favorite Math Story Book* series by the author Zhishang Mofang; *Mathematics Reading* by the author Wu Qingfang; and *Wonderful Math Magic* by the author Luo Youping.

4.3.2 How mathematical problems are developed and solved

Although both Chinese and North American math stories have integrated literature with mathematics knowledge of the same strands, the way they develop and solv their mathematical problems is different.

Table 4.11 and Table 4.12 describe how mathematical problems are posed and solved in 20 Chinese math stories and 20 North American math stories. Of the 20 Chinese math stories, two stories pose more than two problems and the rest put forward a single question. And each problem in Chinese math stories has one single solution. However, of the 20 math stories in North America, eight stories pose more than two problems and four stories put forward one problem where each problem has multiple solutions. The other eight stories in North America do not raise any problems, but show several representations of mathematical knowledge and relationships.

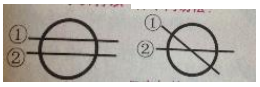
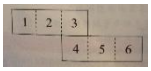
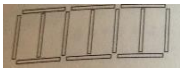
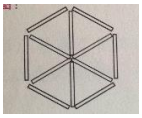
Table 4.11 How Mathematical Problems Are Developed and Solved in Chinese Math Stories

Chinese Math Stories	What is the Problem	How the Problem Solved
Gift Guessing; Pre-Grade Two	What is the number in the blanks: 3, 6, 9, (...), 15, 18, 21, 24, 27; 5, 10, (), (), (), 30?	Finding the patterns: 27-24=3, 24-21=3, 21-18=3 … 10-5=5…
Save the Candy; Pre-Grade Two	How to get a sticker with 20 plum blossoms, and 40 peanuts? How many pudding and peanuts candy do you need to thank your friends? How many pumpkin lanterns will Momo take?	First problem: 4+4+4+4+4=4×5=20, 5×8=40; Second problem: 2×5=10, 8×3=24; Third problem: 3×20=60
Christmas Party; Pre-Grade Two	How to assign tasks for the preparation of Christmas Party?	Build a table.
Angel's Cup Lid; Grade 1	Xiaotiao and Chao broke Angel's cup lid, how much money should each of them pay her?	Cup+Lid=20, Cup-Lid=10 Thus, (20-10) ÷2=5, 5÷2=2.5
Too Many People in the	How many people are there in Angel and her mom's line in	8 people in front of + 3 people behind + Angel and her mom.

Supermarket; Grade 1	the supermarket?	
Drinking Cola; Grade *1*	There are 12 people at Xiaotiao's home, how many bottles of ice tea should they buy?	3+1=4 3+1=4 3+1=4 Buy 9 bottles of ice tea, they can get 12.
Back to HuaGuo Mountain; Grade1-4	There are 49 monkeys in a 7×7 square array. Two of them are too old to stand in the array. Then, how many monkeys can form a square array, and how many monkeys have to leave the array.	Take away a row and a column of 7×7 square array, and the square would become 6×6. 7+7-1=13, 13 monkeys have to leave the array.
Guess What You Think; Grade1-4	Taking a number in mind, add 10, then multiply 3, and then subtract 30. Tell me the result, and then I will know the number in your mind.	If the number in mind is "a," then (a+10) ×3-30=3a
How much is the volume of the Cylindrical Stone?; Grade 1-4	The height of a Cylindrical Stone is 3zhang, 7chi, 5cun, and the bottom circle circumference is 2zhang, 4chi. How much is the volume of the Cylindrical Stone?	3zhang, 7chi, 5cun=37.5chi=12.5m; 2zhang, 4chi=24chi=8m; Radius: 8÷3.14÷2≈1.27m

		1 meter=3chi; Volume: $3.14 \times 1.27^2 \times 12.5 \approx 63.25 m^3$
Measuring the Height of Pyramid; Grade 1-4	How can you measure the height of Pyramid?	He uses a wood stick and a ruler. Until the day the length of the stick's shadow is the same as the stick's length, the height of pyramid can be measured.
Nectar of Bees; Grade 1-4	Each of the three teams gathers 100Jin (1/2 kilogram) nectar from peach, apricot, and pear blossoms. All three kinds of nectars are mixed together. The amount of apricot nectar from the three teams is the same, while peach nectar and pear nectar are all different. The first team gathers more peach nectar than the other groups; the second team's pear nectar is the second largest share of the nine shares; the third team's peach nectar is the largest share of all the nectar. How much did each team gather of each kind of nectar?	The sum of the three nectars in one team is 100, an even number. Therefore, the three numbers have at least one even number. However, all the amounts are prime numbers, the only even number is 2. So the amount of apricot nectar is 2 Jin. Then, resolve 98 into two prime numbers. 98=19+79=31+67=37+61. Therefore, three groups of amount of nectar are 2, 19, 79; 2, 31, 67; 2, 37, 61. The largest share of all the nine shares is 79. Therefore, the first group gathered 79 Jin of peach nectar, 19 Jin of pear nectar and 2 Jin of apricot nectar. The second

		largest share of nectar is 67, which should be the amount of the pear nectar gathered by the second team. So the second group gathered 67 Jin of pear nectar, 31 Jin of peach nectar and 2 Jin of apricot nectar. At last, the third team gathered 61 Jin of peach nectar, 37 Jin of pear nectar and 2 Jin of apricot nectar.
Outwit the Human Trafficker; Grade 1-4	Nine people write three words, "Catch a hare," on a paper in turn with pencils in red and blue. The color of the three words can be the same or different, but at least two of them must be the same. The color of the last one's words must be same as one of the eight above?	Use the figure 0 represent red, 1 represent blue. The 8 possibilities are: 0,0,0; 1,0,0; 0,1,0; 0,0,1; 1,1,0; 1,0,1; 0,1,1; 1,1,1
Ready for Fight; Grade 1-4	Dividing 777 soldiers into 3 parts, the first part has one row, the second part has two rows, and the third part has three rows. If the number of soldiers in each row is the same, how many soldiers in each row?	Total rows: 1+2+3=6; 777÷6=129…3 The number of soldiers in each row is 129 and the leftover three are flag guards standing in front of the array.
Watermelon	If you cut a watermelon only	First cut:

Cutting; Grade 2	two times, how many parts of watermelon can get at most?	 Second cut (two options): 
Folding Carton; Grade 3	Using paper like this:  to fold a carton like this:  ; What is the corresponding figure of 1, 2, and 6?	Solved by looking at the box and paper with spatial visualization.
How to Build a Fence; Grade 3	Xiaotiao's grandfather uses 13 same size wood planks to build six same size pens; however, one of the planks is broken by a little sheep. How can he use 12 same size wood planks to build six same size pens?	The original fence is like this:  Xiaotiao uses 12 wood planks to form a hexagon, like this: 
Red Bean Bun Sharing; Grade *3*	How can 12 children share 7 buns equally?	Cut 4 buns into three pieces, cut 3 buns into four pieces. Each child gets one slice of $\frac{1}{3}$ and one slice of $\frac{1}{4}$ bun.
The Chopsticks	How many squares can be	Xiaotiao's answer is:

on the Table; Grade 3	formed with 6 pairs of chopsticks?	 Xiao Feizhou's answer is: 
Mutton Shashlik; Grade 4	Da pays for 6 Shashlik and Fei pays for 5 Shashlik, and they share all the Shashlik together; Xiaotiao needs to give 5.5 RMB in total to Fei and Da. How much should Xiaotiao give to each of them?	Total money: 5.5×3=16.5 Each price: 16.5÷11=1.5 (Pay) Da: 1.5×6=9, Fei: 1.5×5=7.5 (Return) Da: 9-5.5=3.5, Fei: 7.5-5.5=2
Treating Guests; Grade 6	If he only buys cans of cola, how many cans of cola can Xiaotiao buy?	$(1 - \frac{1}{15} \times 10) \div \frac{1}{24} = 8$

Table 4. 12 How Mathematical Problems Are Developed and Solved in North American Math Stories

North American Math Stories	**What is the Problem**	**How the Problem Solved**
Bean Thirteen; K-Grade 3	How will they escape the curse of bean thirteen?	2×6=12… 1 left 3×4=12…1 left 4×3=12…1 left

		5×2=10…3 left 6×2=12…1 left Eventually, the guests take as much as food s they need, one takes one bean, three take two beans, and two takes three beans.
It's Probably Penny; K-Grade 3	Find different events with varying chances of happening. Make predictions about what will, might, and can't happen.	Lisa writes down predictions, determines the results, and records them.
The Great Graph Contest; K-Grade 3	The snail sets up a contest between Gonk and Beezy to see who can make the best graph.	Gonk and Beezy make different graphs by exploring all aspects of data management in a simple way. Snail makes a new graph as a score sheet which shows that the result is a tie.
Two of Everything; K-Grade 3	There is double of everything because of a magic pot.	Introduction of the concept of doubles.
Give Me Half; Pre-Grade 2	Two siblings cannot share pizza, juice, and cookies equally without parental intervention.	Share equally: $\frac{1}{2}+\frac{1}{2}=1$; 1+1=2

Grandfather Tang's Story; Pre-Grade 2	Two competitive foxes go through physical transformations until a hunter's arrow reminds them of true friendship.	Shape-changing of tangrams.
Amanda Bean's Amazing Dream; Pre-Grade 3	How many wheels? How many legs? How many knitting needles? ...	2×8=16, 4×8=32, 5×8=40 2×7=14 …
Anno's Magic Seeds; Pre-Grade 3	Readers are challenged with these questions: How many seeds did Jack bury? How many seeds grew that year?	1st year: 2×2=4, eat one, plant 3; 2nd year: 3×2=6, eat one, plant 5; 3rd year: 5×2=10, eat one, plant 9; And so forth…
A Remainder of One; Pre-Grade3	How can 25 bugs march in even lines so that no one will be left out?	2×12=24…1 left 3×8=24…1 left 4×6=24…1 left 5×5=25 That's it!
One Grain Of Rice: A Mathematical	A selfish raja collects all the rice from the people, and the people have nothing to eat until	She asks the raja to simply double the amount of rice each day.

Folktal; Pre-Grade 3	a famine. A clever girl outsmarts the raja, turning a reward of one grain of rice into a feast to save her village.	Day 1: 1 Day 2: 2 Day 3: 4 Day 12: 2,048 Day 13: 4,096 Day 16: 32,768 Day 21: 1,048,576 Day 24: 8,388,608 Day 30 : 536,870,912
Stay in Line; Pre-Grade 3	When 12 children take a class trip to the zoo, they discover many ways of lining up.	$2 \times 6 = 12$ $3 \times 4 = 12$ $12 \times 1 = 12$ $8 + 4 = 12$ $2 + 2 + 2 + 3 + 3 = 12$
The Doorbell Rang; Pre-Grade 3	How can you share 12 cookies equally with 2, 4, 6, and 12 friends?	$2 \times 6 = 12$ $4 \times 3 = 12$ $6 \times 2 = 12$ $12 \times 1 = 12$
Tally O'Malley; Grade 1 and up	On a long car trip, kids play tally games to keep busy.	They count using the mark below:

		
Spaghetti and Meatballs For All; Grade 1-3	There are 8 tables and 32 chairs for 32 people. When the guests rearrange the furniture so they can sit together, it results in a big mess, until the original configuration evolves again.	Table=Area, Chair=Perimeter If the area of 8 tables is 8, the perimeter could be: $6 \times 4=24$ $(2+3) \times 2+6=16$ $(2+4) \times 2=12$ $8 \times 2=16$ $(8+1) \times 2=18$ $4 \times 8=32$
A Place For Zero; Grade 1-4	What would happen if zero was multiplied with another number? What number can you get if you add 1 to 9?	$0 \times 1=0$, $0 \times 7=0$; $9+1=10$, then 20, 30, … 90; $10 \times 10=100$, then 500, … 700 … 900
Sir Cumference and the Isle of Immeter; Grade 1-7	How to calculate the perimeter and area of a circle to unlock the island's secret?	Cut the circle into eight equal pieces to form a rectAngel. Long side of rectangle= $\frac{1}{2}$ circumference; Short side of rectangle=radius

Jump, Kangaroo, Jump; Grade 2 and up	Kangaroo and his friends are divided into teams to compete in Field Day exercises.	6 is $\frac{1}{2}$ of 12; 4 is $\frac{1}{3}$ of 12; 3 is $\frac{1}{4}$ of 12
Lemonade For Sale; Grade 2 and up	Kids in a club decide to sell lemonade to make money and want to keep track of the sales.	Sheri makes a bar graph to list the number of cups up the side and the days of the week along the bottom.
Mummy Math: An Adventure in Geometry; Grade 2-5	Matt and Bibi get trapped in the pyramid and they use their math skills to find the way out.	Counting the faces, the flat surfaces of geometric solids.
Counting on Frank; Grade 4 and up	If you drew a straight line with a ball point pen until it ran out, how long would the line be? If you ran a bath until the room filled up with water, how long would it take? What if… (12 questions included in this story)	Measuring the world in a unique way by estimating the sizes.

In order to better understand how mathematical problems are developed and solved in each group of stories, the comparison of three pairs of Chinese and North American math stories is discussed below.

Stories 1 and 2. Figure 4.9 is a Chinese math story entitled *Too Many People in the Supermarket* for students in the level of Grade One, and Figure 4.10 is a North American math story called *Stay in Line* for students from Preschool to Grade Three. Both stories address mathematical knowledge in the area of Number Sense and Numeration.

The following is the translation of Chinese math story *Too Many People in the Supermarket*:

Paragraph One: Every weekend, Angel's mom would take her to the supermarket. This Saturday, Angel's mom took her to the supermarket near their home as usual. Angel's mom was pushing a shopping cart and Angel helped her mom take the shopping bag. They were shopping happily in the supermarket.

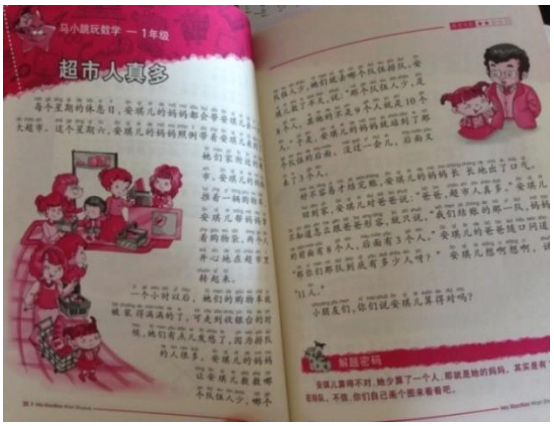
Paragraph Two: An hour later, their shopping cart was full of things. When they went to check out, they felt a little bit worried because many people were waiting in line. Angel's mom asked her to count the number of people in each line and they would go to the line with the fewest people. Angel counted for a few minutes, then pointed to a line and said, "That one only has eight people in line, and the other lines have either nine or ten people." Then, Angel's mom went to the back of that line and waited there. After a while, three people were waiting in line behind them.

Paragraphs Three to Four: Angel and her mom were waiting for a long time, and they felt so relieved when they finished with the check out. After arriving home, Angel told her Dad there were too many people in the supermarket. However, she didn't know how to describe the details and just said, "When we were checking out, there were eight people in front of us and three people behind us." Angel's Dad asked casually, "Do you

how many people there were in your line?" Angel thought for a moment and said, "Eleven!"

Paragraph Five: Dear children, do you know whether Angel's answer is correct or not?

Figure 4. 9 Example One (Chinese story): *Too Many People in the Supermarket*



In this Chinese story, the mathematical problem appears during the conversation between Angel's Dad and Angel and the situation of the mathematical problem comes from the checkout line in the supermarket. There are eight people standing in front of Angel and her mom and three people behind. This is a counting problem or an addition problem. In order to calculate the total number of people in the line, Angel needs to add the number of people in front of them, behind them, and herself and her Mom. The answer Angel gave to her Dad is eleven. In the last paragraph of the story, the author puts forward a closed question to the reader "Does Angel's answer correct?" Obviously, Angel only adds the eight people standing in front of her mom and three behind together, while forgetting that she and her mom were also in line. The author also offers a

suggestion at the end of the story that children could draw a picture of the checkout line and count the number of people in line one by one.

The mathematical problem in the North American math story is developed in a different way. The following is the text of the story *Stay in Line*:

"Twelve girls and boys set off for the zoo.

Six pairs of children lined up, two by two.

Everyone groaned when the teacher said "Class, please stay in line. Do not run ahead"

But staying together turned out to be fun. There were so many ways that it could be done.

One dozen children marched out the doors. Three rows of children marched out in fours.

Twelve boys and girls climbed onto the bus and sat three by three, without any fuss.

At the zoo, all the children skipped through the gate.

There was one line of four and one line of eight.

Then twelve happy children, each with a smile, skipped toward the henhouse. They skipped single file.

The whole class wanted to look at the chicks. So they crowded around them in two rows of six.

At the llamas the children could see for themselves that the best way to stand was in one row of twelve.

Later, the children got down on their knees to play with the bunnies in twos and in threes.

Then all in a bunch, the class fed the pigs lunch, gave the ponies some oats, and petted the goats.

By the time they had seen every inch of the zoo, there was only one thing the kids wanted to do.

"You all must be tired," their teacher guessed. "Why don't we relax now and take a short rest?"

So twelve tired children plopped down in a heap. And, still all together, they fell fast asleep."

Figure 4. 10 Example Two (North American story): *Stay in Line*

This North American math story expresses how one dozen children can be grouped in different ways, like 1 x 12, 2 x 6, and 3 x 4. In addition, this story also shows children how to count things of a dozen, such as 2, 4, 6, 8… or 3, 6, 9, 12 (see from Figure 4.10). Even though there is no real question raised at the end of this story, it actually provides a way for children to count in a variety of ways, and to develop a sense of number. It also gives the teacher the opportunity to pause and ask the children what they notice in the picture on each page, and how it is similar or different from the previous page. This story focuses on the number 12 and the different ways it can be represented as an array or combinations of arrays; however, children can expand to other numbers with the same counting method.

The Chinese story puts forward a problem of calculating the number of people in line and the main character in the story provides an answer to this problem. At the end of the story, the author asks the readers to judge whether that answer in the story is correct. The Chinese story has a problem to solve, but offers an incorrect result. Therefore, the readers are expected to identify the mistake and correct it. The North American story presents a situation that shows children how the number 12 can be represented and counted in a variety of ways. Seeing 12 as arrays of 1 x12, 2 x 6, and 3 x 4, helps students develop ways of counting to 12 by different steps (by 1s, 2s, 3s, 4s and 6s), and leads to an understanding of multiplication (such as, three fours make 12). The North American story focuses on conceptual understanding, while the Chinese story focuses on problem solving.

Stories 3 and 4. Below I discuss two other stories: *Drinking Cola* in China for Grade One students, which is similar to *Too Many People in the Supermarket*, but corrects the error in the story, and *The Doorbell Rang* in North America for the students from Preschool to Grade three, which is similar to *Stay in Line*, but also asks questions to solve.

The following is the translation of Chinese math story *Drinking Cola*:

Paragraph One: Xiaotiao loves drinking cola. Whenever he goes to the supermarket with his mom, he asks his mom to buy cola for him. However, Xiaotiao's mother thinks cola is not good for his health. One Saturday afternoon, Xiaotiao goes to the supermarket again with his mom. Luckily, Pepsi Cola is doing a sales promotion where Xiaotiao can get one free bottle of cola by providing four empty bottles.

Paragraph Two: Xiaotiao is so excited because he hasn't drunk cola for a long time. He begs, "Hey, dear mom, you see, we can drink five bottles of coke while only paying for four! Can we…?" His mom knows what Xiaotiao is thinking and she laughs, "Well, let me see, if you can answer my question correctly, you can enjoy your cola today." "Sure!" Xiaotiao answers happily. "Listen carefully, here's the question. If we buy 16 bottles of Pepsi now, how many bottles of cola can you drink?" "Ha, that's easy!" Xiaotiao answers, "If we buy 16 bottles, I will have 20 bottles!" Xiaotiao laughs loudly as if the bottles of cola have been put before him.

Paragraph Three: However, at the moment Xiaotiao's mom shakes her head, and says, "Well, it's time to go home now. Say goodbye to your cola." "What? Am I wrong?" Xiaotiao stamps his feet anxiously. "You are a little muddle head! If we buy 16 bottles, I can drink one more bottle than you!" Xiaotiao rethinks carefully and finds his mistake. He glances at the cola on the goods shelf and goes back home.

Figure 4. 11 Example Three (Chinese story): *Drinking Cola*

This Chinese story presents another type of counting problem; however, it is a single solution question. The key information in this story is "Provide four empty Pepsi bottles, get one bottle free" which shows each one of the four plus one. Sixteen can be split into

four groups of four, and each of the group can add one. Therefore, Xiaotiao gives the answer twenty. However, he forgets that the plus one in each group can form a new group of four and then he could get another one free. This is also why Xiaotiao's mom says that she can drink one more bottle than Xiaotiao.

The North American math story *The Doorbell Rang* also asks questions to solve, but the mathematical problem is developed in different way. The following is the text of the story *The Doorbell Rang*:

"I've made some cookies for tea," said Ma. "Good," said Victoria and Sam. "We're starving." "Share them between yourselves," said Ma. "I made plenty."

"That's six each," said Sam and Victoria. "They look as good as Grandma's," said Victoria. "They smell as good as Grandma's," said Sam.

"No one makes cookies like Grandma," said Ma as the doorbell rang.

It was Tom and Hannah from next door. "Come in," said Ma. "You can share the cookies."

"That's three each," said Sam and Victoria. "They smell as good as your Grandma's," said Tom. "And look as good," said Hannah.

"No one makes cookies like Grandma," said Ma as the doorbell rang.

It was Peter and his little brother. "Come in," said Ma. "You can share the cookies."

"That's two each," said Victoria and Sam. "They look as good as your Grandma's," said Peter. "And look as good."

"Nobody makes cookies like Grandma," said Ma as the doorbell rang.

It was Joy and Simon with their four cousins. “Come in,” said Ma. “You can share the cookies.”

“That’s one each,” said Sam and Victoria. “They smell as good as your Grandma’s,” said Joy. “And look as good,” said Simon.

“No one makes cookies like Grandma,” said Ma as the doorbell rang. And rang.

“Oh dear,” said Ma as the children stared at the cookies on their plates. “Perhaps you’d better eat them before we open the door.” “We’ll wait,” said Sam.

It was Grandma with an enormous tray of cookies. “How nice to have so many friends to share them with,” said Grandma. “It’s a good thing I made a lot!”

“And no one makes cookies like Grandma,” said Ma as the doorbell rang.

Figure 4. 12 Example Four (North American story): *The Doorbell Rang*

This story provides the problem of how to equally share twelve cookies between friends. Two people, six each; four people, three each; six people, two each; twelve people, one each. It shows math content similar to the story *Stay in Line,* where 12 can be presented in a variety of ways (a variety of rectangular arrays), such as 2 x 6, 4 x 3, 12 x

1 which also gives an introduction to addition (i.e., 4 + 4 + 4 = 12), multiplication (i.e., 3 x 4 = 12) and division (i.e., 12 ÷ 3 = 4).

Both the Chinese and North American stories contain problem solving in the storyline. The Chinese story expresses the problem by giving an error answer and correcting it, but there is a single solution. However, the North American story provides a variety of ways to share a certain number of cookies between people in different quantities. The story in North America brings out the process of problem solving in different ways. The nature of Chinese story is to propose a math question with a real life context, while the North American story focuses on the conceptual understanding of math concepts.

It is also interesting to note that, for the stories considered so far, the Chinese stories tend to focus on one problem to be solved, which is presented near the end of the story, while the North American stories present a number of conceptual representations and/or questions throughout the story. For example, at the end of Chinese math story *Too Many People in the Supermarket*, the author puts forward the question, "Dear children, do you know whether Angel's answer is correct or not?" The author doesn't give a correct answer by the main character, but asks readers to think and correct at the end of the story. In Chinese story *Drinking Cola*, it says Xiaotiao's mom gives a different answer and Xiaotiao rethinks and finds his mistake at the end of story. However, for the North American math stories, like *The Doorbell Rang*, when the new guests join and sit down, one of them points out how to share the cookies this time. Each time the doorbell rings in this story, a new solution to sharing cookies is given by the children. In addition, all the activities in *Stay in Line*, like "Six pairs of children lined up, two by two," "Three rows of

children marched out in fours," or "The children got down on their knees to play with the bunnies in twos and in threes," show different patterns of number 12. In this story, each pattern of number 12 is displayed by children's actions during the journey to the zoo.

Stories 5 and 6. Below I discuss two math stories dealing with the concept of Fractions. The Chinese story *Red Bean Bun Sharing* for the level of Grade Three, and *Jump, Kangaroo, Jump* in North America for the level of Grade Two and up.

The following is the translation of Chinese math story *Red Bean Bun Sharing*:

Paragraph One to Two: During the summer vacation, Xiaotiao's parents still need to go to work as usual. Therefore, Xiaotiao and Xiaozhou feel very bored at home. Xiaozhou taps Xiaotiao on his shoulder and asks, "Hey, shall we invite some friends and have fun together?" "Sounds great," Xiaotiao says and jumps down from the bed immediately and starts calling his friends. He calls his best friends Chao and Fei first. Then, Chao and Fei invite Da and Wentao. Wentao tells Linguo to come and Linguo brings Manman as well. Angel also comes to join them. At noon, Xiaotiao's home is full of people. Xiaotiao counts the scattered shoes at the door- 10 pairs of shoes there. It shows that, including Xiaotiao and Xiaozhou, there are 12 people at Xiaotiao's home now.

Paragraph Three to Six: Time flies and in no time it is noon. The little kids begin to feel hungry. Xiaotiao tries to find something to eat in the kitchen, but only 4 red bean buns are left in the fridge. "4 red bean buns are far from enough!" Xiaotiao feels anxious. At this moment, Chao slips into the kitchen as well. Xiaotiao complains to Chao, "There are only 4 red bean buns in the fridge! How can we fill our empty stomachs?" Chao looks

around and opens the cover of the cooking pot. Another 3 red bean buns are lying there. “Don’t worry! There are 3 more of them!”

Paragraph Seven to Nine: Xiaotiao counts for a while and says, “Well, how can we split the 7 red bean buns by 12 people? If every people eat one red bean bun, another 5 red bean buns are needed. If every people eat only half of a dumpling, there will be one left.” Xiaotiao sighs, “It’s my fault. I should have thought about the lunch problem!” “That’s all right. Let’s just find a way to split the red bean buns!” Chao comforts him. “Well,” Xiaotiao puts all the red bean buns together and stares at them for almost a minute. Suddenly, he shouted, “I’ve got it!” Then, he picks up the knife and starts to slice the red bean buns. Chao is impressed by Xiaotiao’s method and then gives him a big thumb up.

Figure 4. 13 Example Five (Chinese story): *Red Bean Bun Sharing*

This Chinese story is similar to the North American story, *The Doorbell Rang*, in that both of them talk about sharing. The difference is that the problem the Chinese story posed is how to equally share seven buns between 12 kids. At the end of the story, the author presents the picture of the cutting red beans buns which shows that four of the buns are divided into three parts, the other three buns are split into four parts (see Figure

13). In other words, each kid can share one $\frac{1}{3}$ part and one $\frac{1}{4}$ part. In contrast to *The Doorbell Rang*, the seven buns in this Chinese story cannot be split by a whole number. Considering three fours make twelve, the seven buns are divided into a group of three and a group of four. This is also indicated in the storyline that four buns are found first and then another three. Then the buns in the group of four and three are cut separately according to the division of twelve that $12 \div 4 = 3$ and $12 \div 3 = 4$. This story introduces fractions to kids by means of multiplication and division, resulting in fractions that make 12 parts.

There are other solutions to this problem. For example, twelve can also be represented as two sixes, then the seven buns can be divided into a group of one and a group of six, and buns in the group of six can be split into two parts each and the bun left over can be cut into twelve parts. However, the author doesn't list this possibility here. This kind of solution cannot be judged as false; it can only be considered that there are many ways to divide a bun into 12 pieces in real life situations. However, so far there is a pattern developing in the Chinese stories, where the focus is on a single solution.

The following North American math story *Jump, Kangaroo, Jump* develops the same mathematical concept, but explores more possibilities. The text of this story is as follows:

"It's Field Day," yelled Kangaroo. There were twelve campers in all: a kookaburra, an emu, two platypuses, three koalas, four dingoes, and Kangaroo himself. They warmed up as they waited for Ruby, the kangaroo counselor, to start the events.

Finally Ruby blew her whistle and said, “We need two teams for tug-of war. Let’s split the group into halves so that each team has the same number of campers. They counted off into two teams. There were six campers on each team. Each team had $\frac{1}{2}$ of the campers. 6 is $\frac{1}{2}$ of 12. The campers tugged and grunted. And then they tugged some more. Both teams tugged very hard.

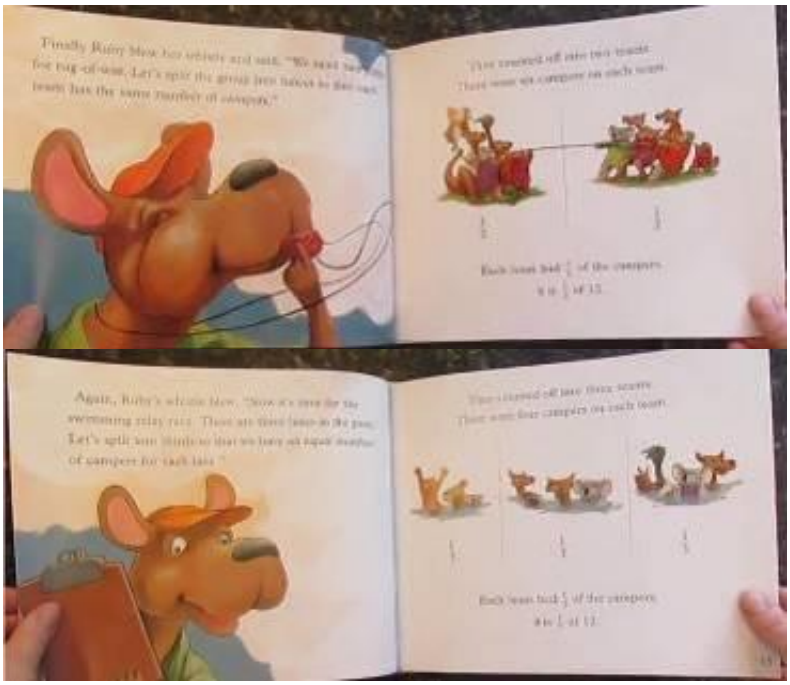
Again, Ruby’s whistle blew. “Now it’s time for the swimming relay race. There are three lanes in the pool. Let’s split into thirds so that we have an equal number of campers for each lane.” They counted off into three teams. There were four campers on each team. Each team had $\frac{1}{3}$ of the campers. 4 is $\frac{1}{3}$ of 12. They kicked and splashed. And then they kicked some more. All the campers swam just as fast as they could.

Ruby blew her whistle once more. “Next we’ll use our four canoes for a race on the lake. We need to split the group into fourths so that we have an equal number of campers in each canoe.” They counted off into four teams. There were three campers on each team. Each team has $\frac{1}{4}$ of the campers. 3 is $\frac{1}{4}$ of 12. They paddled and pulled. And then they paddled some more. They paddled just as hard as they could. They did their very best, but Kangaroo’s team tied for last place. He wished that he could win just once. “Cheer up, Kangaroo” said Ruby. “You still have one more chance.”

“Okay, everyone!” Ruby yelled, and then blew her whistle extra loud. “Let’s line up for the last event of the last event of the day- the long jump. This time, you’re on your own.” Each camper took a turn jumping. Finally, it was Kangaroo’s turn. Everyone yelled, “Jump, Kangaroo, Jump!” He closed his eyes, sprang forward on his big hind legs, and jumped just as far as he could.

Kangaroo looked around in surprise as everyone cheered. Then, Ruby announced, “Kangaroo not only won the long jump, he set a new camp record.” “HOORAY FOR KANGAROO!”

Figure 4. 14 Example Six (North American story): *Jump, Kangaroo, Jump*



This North American story includes some of the same math concepts that are presented in *The Doorbell Rang*, and in *Stay in Line*, such as different ways of dividing twelve into equal groups. It also discusses fractions by splitting the same number of campers on each team for competition. Compared with the above Chinese story *Red Bean Bun Sharing*, this story lists more options of fractions within the number twelve.

Both of the two stories contain the math concepts: problem solving and fractions. However, North American story provides more patterns to divide twelve than Chinese story does. The Chinese story raises the question in the story, but it does not provide the solution in the storyline. Instead, it leaves the solution to the reader. After reading the story, readers can see the single solution the author provided. By contrast, in the North American story, like the story *The Doorbell Rang*, students are given opportunities to think about and answer the questions, as the solution is not shown until the page is turned.

North American math story explains how to solve the problem in the storyline, as did the story *Stay in Line*, and also offers more opportunities for readers to understand the fractions related with the number 12.

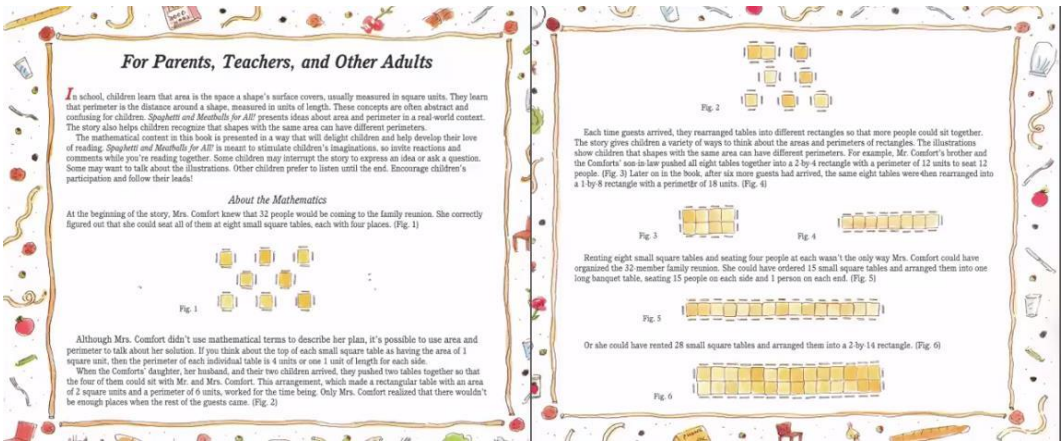
4.3.3 Pedagogical development

Section 4.3.2 describes what the mathematics problem is and how it is solved in 20 Chinese and 20 North American math stories, focusing on the mathematics processes used. This section looks at problems and solutions in math stories from the perspective of pedagogical development.

As mentioned in Table 4.11, the problems posed in Chinese math stories can be categorized as the following types: "How many/How much…?" (13), "How to…?" (4), "What is…?" (2). All these problems in Chinese math stories have a single solution. Problems in North American math stories (see Table 4.12) are summarized as: "How to…" (7), "How many…?" (2), "What would/might…/What if…?" (3). The solutions of each problem use a variety of patterns in North American math stories. And we can see this also in the stories just examined in previous section, for example the Chinese math story *Drinking Cola*, and North American math story *The Doorbell Rang*. Both the Chinese and North American math stories are problem-based; however, the Chinese math stories focus on giving problems to solve, and presenting more calculation problems, with closed-ended questions. North American math stories are different in that they present various representations of knowledge and give more open-ended problems and offer multiple representations.

Another key difference is that many math story books in North America have a section called “Tips for Parents and Teachers” at the end of the book; however, none of the Chinese math story books have such tips. The nature of the tips varies in different books, but typically includes two parts: (1) illustration of mathematical knowledge mentioned in the math story and (2) extension activities. Figures 4.15 and 4.16 show the Tips for Parents, Teachers and Other Adults from *Spaghetti and Meatballs for All* and *Amanda Bean's Amazing Dream*, respectively. The tips in Figure 4.15 present ideas about the area and perimeter in a real world context, and illustrate each pattern of math concepts through the story. The tips in Figure 4.16 talk about the mathematics knowledge-multiplication illustrated in the story and then introduces extended activities to help students count objects. The section “Tips” in North American math story books give opportunities for parents and teachers to extend to other mathematical problems and they offer a pedagogical focus that is lacking in the Chinese math stories.

Figure 4. 15 Example One (North American story): Tips



For Parents, Teachers, and Other Adults

In school, children learn that area is the space a shape's surface covers, usually measured in square units. They learn that perimeter is the distance around a shape, measured in units of length. These concepts are often abstract and confusing for children. *Spaghetti and Meatballs for All!* presents ideas about area and perimeter in a real-world context. The story also helps children recognize that shapes with the same area can have different perimeters.

The mathematical content in this book is presented in a way that will delight children and help develop their love of reading. *Spaghetti and Meatballs for All!* is meant to stimulate children's imaginations, so invite reactions and comments while you're reading together. Some children may interrupt the story to express an idea or ask a question. Some may want to talk about the illustrations. Other children prefer to listen until the end. Encourage children's participation and follow their leads!

About the Mathematics

At the beginning of the story, Mrs. Comfort knew that 32 people would be coming to the family reunion. She correctly figured out that she could seat all of them at eight small square tables, each with four places. (Fig. 1)

Fig. 1

Although Mrs. Comfort didn't use mathematical terms to describe her plan, it's possible to use area and perimeter to talk about her solution. If you think about the top of each small square table as having the area of 1 square unit, then the perimeter of each individual table is 4 units or one 1 unit of length for each side.

When the Comforts' daughter, her husband, and their two children arrived, they pushed two tables together so that the four of them could sit with Mr. and Mrs. Comfort. This arrangement, which made a rectangular table with an area of 2 square units and a perimeter of 6 units, worked for the time being. Only Mrs. Comfort realized that there wouldn't be enough places when the rest of the guests came. (Fig. 2)

Fig. 2

Each time guests arrived, they rearranged tables into different rectangles so that more people could sit together. The story gives children a variety of ways to think about the areas and perimeters of rectangles. The illustrations show children that shapes with the same area can have different perimeters. For example, Mr. Comfort's brother and the Comforts' son-in-law pushed all eight tables together into a 2-by-4 rectangle with a perimeter of 12 units to seat 12 people. (Fig. 3) Later on in the book, after six more guests had arrived, the same eight tables were then rearranged into a 1-by-8 rectangle with a perimeter of 18 units. (Fig. 4)

Fig. 3

Fig. 4

Renting eight small square tables and seating four people at each wasn't the only way Mrs. Comfort could have organized the 32-member family reunion. She could have ordered 15 small square tables and arranged them into one long banquet table, seating 15 people on each side and 1 person on each end. (Fig. 5)

Fig. 5

Or she could have rented 28 small square tables and arranged them into a 2-by-14 rectangle. (Fig. 6)

Fig. 6

Figure 4. 16 Example Two (North American story): Tips

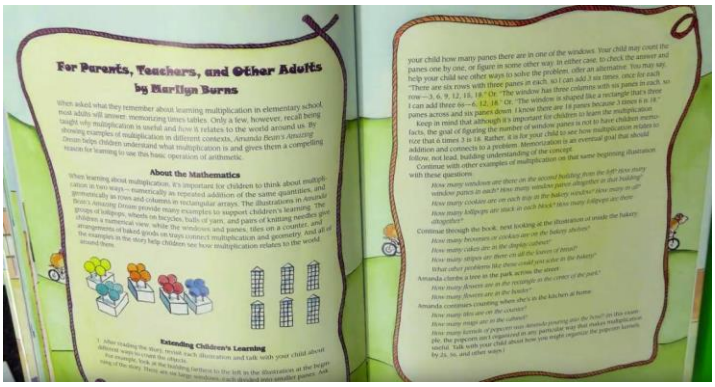


Table 4. 13 The Characteristics of the Above Math Stories

Chinese stories	North American stories
▫ pose a single problem	▫ pose several questions and/or show several representations
▫ problem is posed at the end of the story	▫ questions/representations are given throughout the story
▫ only one solution is offered	▫ multiple solutions/representations are offered
▫ always poses a problem to be solved by the reader	▫ sometimes no questions are asked of the reader, and only various representations/solutions are depicted
▫ closed-ended problems	▫ open-ended problems

In sum, both math stories in China and North America try to integrate problem solving and mathematical concepts into the story. Chinese stories always ask a single question at the end of the story and they either only have one solution to the question or let the reader to solve the problem. However, stories in North America always provide more than one question and offer more solutions to a single question throughout the whole story. Some North American stories also have no questions, but only show the

representations with the plot development. Generally, Chinese math stories emphasize the solving of a closed-ended problem, while stories in North America focus on the open-ended problems and the description of various patterns of mathematical knowledge, focusing on conceptual understanding of mathematics.

4.4 Summary

The purpose of this study is to compare the similarities and differences of math stories in China and North America. This chapter compares the math stories in China and North America from the perspective of physical characteristics, plot development and mathematical development. Themes that emerged from the comparison with selected stories include the length, size, color, image, and cost of story books, the setting, characters, roles in posing and solving problems of the stories, and the math strands, math problems, and pedagogical development inside the story. Through the analysis of math stories from three dimensions, it can be found that there are more differences than similarities between Chinese and North American math stories. The discussions of these findings with respect to the reviewed literature will be presented in the next chapter.

CHAPTER 5: DISCUSSION

5.1 Problem Revisited

This research study involves comparing 20 Chinese math stories and 20 North American math stories with the intent to answer the following question:

> *What are the similarities and differences of math stories in elementary mathematics education in China and North America?*

More specifically, the study compares math stories in China and North America from the perspective of physical characteristics, plot development and mathematical development, in order to develop a sense about the similarities and differences of math stories in China and North America.

5.2 Similarities and Differences

From the comparison of math stories in Chapter 4, an image of math stories in China and North America emerged that shows more differences than similarities. First, from the perspective of physical characteristics, math stories in China and North America have common grounds in their length and font size (focusing on the text of the math stories). However, they differ in a number of ways: (1) the number of pages of a single story book is much greater in China than in North America; (2) the color spectrum used in China usually involves two colors while a full-color spectrum is used in North America; (3) the position of images are on the side in China while centered in North America; (4) the ratio of images to text is much greater in North America than in China; 5) the meaning of text matches with the image on each page in North America, however, the pictures only

match with part of the text; and 6) the relative cost of Chinese story books is more expensive for Chinese citizens than North American books for North American citizens.

Second, in terms of plot development, although Chinese and North American math stories have similarities in most story settings and characters' roles, it is evident that there are some differences: 1) some North American stories happen in one's dream or imagination while Chinese stories don't have this feature; 2) the age span of lead characters is wider in North America than in China; 3) Strangers is one of the relationships between characters, in China while not appearing in North America, 4) the ratio of male to female characters is more balanced in North America than in China; 5) the characters' roles in posing and solving problems are more varied in North American than in China; and 6) some characters in Chinese stories solve the problems with others' help, however, no one explicitly offers children any help in problem solving in North America, although there is scaffolding through helpful representations of ideas.

Third, on the side of mathematical development, both Chinese and North American math stories have more focus on the strand of Number Sense and Numeration and try to integrate problem solving with mathematical concepts; however, they are different in five ways: 1) there are more stories posing several problems or showing multiple representations in a single story in North America than in China; 2) all the problems have a single solution in China while some North American problems have multiple solutions or representations; 3) problems in China are posed at the end of the story while but are posed throughout the story in North America; 4) math problems in China focus on calculations which are closed ended problems while North American stories have more

open-ended problems; and 5) North American stories offer tips at the end of books for pedagogical development while Chinese stories do not.

5.3 Math Education System

Looking back to the Literature Review, there are number of themes related to the findings: teaching and learning mathematics, the nature of mathematics, and the learning environment. Below, I will use each of these themes as lenses for analyzing the findings.

5.3.1 Teaching and Learning Mathematics

We see in the literature review that there are differences in the teaching and learning of mathematics in China and North America. Mathematics teaching in China is teacher-centered in that teachers control how to teach and at what pace, while the teaching method adopted in North America is inclined to be student-centered (Norton & Zhang, 2013; Pang, 2000). Chinese students are accustomed to memorizing the definition of mathematical knowledge before seeking to understand the function of the material (Li, 2004). However, North American students are encouraged to actively participate in various mathematical activities (Pang, 2000).

Looking at the math stories in this study, it appears that these differences in teaching and learning are also evident. In the North American stories examined in this study, the child characters participate mathematically throughout the stories. Questions are posed and mathematical situations are created where children have to think about mathematics in different ways as the story progresses. Thus, there is a lot of participation of the children in mathematics, throughout the story. For example, we saw in the story *The Doorbell Rang* that each time the doorbell rings, more friends join in, and then the

children need to redistribute the cookies with different numbers of people. The doorbell rings four times throughout this story, and each time the doorbell rings, the children are discussing a new way to share cookies. Children participate in sharing 12 cookies mathematically through the story.

In the Chinese math stories examined in this study, there is no explicit involvement of mathematics until the end of the math stories. Near the end of the story, a problem is posed and when the child characters give the wrong answer, the adult character offers a hint for them to find the right answer. Unlike the North American stories where children have opportunities to engage with the mathematics from various perspectives, in the Chinese stories the "teaching" and "learning" is narrowly focused on a problem and its correct answer and only at the end of the story. For example, we see in the story *Drinking Cola*, a question about “how many bottles of cola can we get if we buy 16 bottles?” is posed by Mom near the end of the story, and a wrong answer is given by the child. Then, the Mom suggests the child that his solution is incorrect and tells him that she could drink one more bottle than him. At the end of the story, the author just says that the child rethinks the problem and understands why he drinks one less than Mom. None of the process of how to get the result twenty-one is shown in the story. Children only participate mathematically by giving a wrong solution at the end of the story.

5.3.2 The Nature of Mathematics

In terms of the nature of mathematics, differences between China and North America have been mentioned in Literature Review. A study conducted by Zhu and Fan (2006) suggests that the distribution of different types of problems in mathematics class is more balanced in North America than in China. Chinese mathematics education tends

to provide puzzle problems while North America has more types of non-traditional and non-routine problems, including project-problems and journal writing problems. Due to the severe competitiveness of entering colleges, the teaching of techniques for test-taking is the main content in mathematics class in China (Chang, 1984). Basic computational skills are regarded as the foundation of problem solving learning (Zhang, Li, & Tang, 2004). Therefore, problems involved with calculation are always posed in Chinese mathematics class in order to improve students' computational ability. However, in North America, the conceptual understanding of mathematical concepts and the cultivation of critical thinking are valued highly (Sztein, Olson, & Ferreras, 2010).

In judging the nature of mathematics, this thesis uses the theory of constructivism. There are two key themes in constructivism, and both of them are used to frame the following discussion: first, there is a focus on conceptual understanding, and second, there is a focus on students as active learners, which means students have to construct their own understanding. As noted earlier in the section on the limitations of the study, constructivism is a theory chosen from Western culture, and the judgments made in this thesis about the nature and quality of mathematics in Chinese stories may introduce a cultural bias.

Looking at the mathematical development in math stories in this study, it appears that the nature of mathematics in math stories in China and North America is different as well. The mathematics in Chinese stories is puzzle-based or single answer based, and the mathematics in North American stories is more focused on conceptual development and on seeing or exploring multiple representations. In this study, each mathematical problem in Chinese math stories corresponds to a single solution, and most problems have more to

do with calculation, such as, “How many cans of cola could we buy with the money?” “How much money should we pay?” For example, in the Chinese story *Too Many People in the Supermarket*, a single problem about “how many people are there in the line?” is posed, which is an addition problem and there is only one way to solve it.

However, most North American math stories pose several problems in a single story, or show various representations, and each problem has multiple solutions or representations. For example, in the story *Stay in Line*, various formations of 12 students are described as different representations for the number 12. Each formation of the 12 students represents a way of showing the number 12. Furthermore, stories in North American also have problems which include “What if…?” or offer some hints which are to let students think and imagine what would happen next. For example, at the end of the story *The Doorbell Rang*, the doorbell rings again and students would think how to share 12 cookies with more than 12 people, which would help students extend their knowledge.

It appears that closed ended problems dominate mathematics problems in Chinese math stories, while North American math stories pose more open-ended problems. The multiple solutions/representations in North American stories can make a difference in experiencing a mathematical concept from different perspectives, while the single solution problems in China only give the result directly. It seems that Chinese math stories focus on the posing of problems while ignoring the integration of mathematics throughout the story. However, mathematics knowledge in North American stories is organized in a progressive way which contributes to the conceptual understanding of mathematics.

This is contrary to the intent of the current Chinese mathematics curriculum which states that: “Mathematics should enable students to master basic skills, reasoning ability, and practical ability” (Ministry of Education, 2011, p. 3). It suggests that mathematics in China is supposed to focus on the cultivation of mathematical thinking and the application of mathematical knowledge. With the curriculum reform recently in China, mathematics education is expected to shift from the high requirement of students’ computation ability to the application of mathematics knowledge in real-life situations, and the utilization of various methods to solve a problem (Ministry of Education, 2011). Teachers are expected to introduce more methods in solving problems and students are encouraged to spend more time in proofs of concepts instead of rote drilling. In this study, we can see that Chinese math stories create a real life situation first and then pose a related mathematical problem. However, the stories do not discuss how to solve the problem or engage students with different ways to solve the problem. Chinese stories address some of the requirements of the current curriculum, but miss others. This suggests that to better match the current curriculum, Chinese math stories would need to focus more on the analysis of mathematics concepts, rather than simply pose a single solution problem to examine whether children are able to get the correct result.

However, looking at the North American curriculum, we can see that North American math stories mirror the principles of current mathematics curricula well. Similar to Chinese curriculum, the current Ontario curriculum also states that,

> “Mathematics learning is more than a mastery of basic skills, but also a powerful tool for reasoning, justifying, and expressing; the identification of relationships between mathematical concepts and everyday situations would help students

> extend and apply their knowledge in other areas, including other subjects, daily lives and workplace" (Ontario Ministry of Education, 2005, p. 3).

Students are expected to build a solid conceptual foundation in mathematics to help them apply their knowledge in further study successfully. In order to do this, mathematics education is focused on the illustration of knowledge in a variety of ways to help promote the understanding of mathematical concepts. It suggests that there should be an emphasis on the explanation and discussion of fundamental mathematical concepts to improve children's understanding, and this matches quite well with the focus of North American stories in this study.

5.3.3 Learning Environment

Looking at the learning environment in China and North America, several differences appear. In China, each mathematics classroom has about 40-50 students while in North America, the number of students is 20-30. The smaller class size makes it easier for students in North American classrooms to be provided opportunities to participate in hands-on mathematical activities and group discussions, and to express their own ideas and to doubt and discuss those of others. The desks in Chinese mathematics classroom are all facing the teacher; however, in North America desks are able to be clustered into groups which is convenient for students to work collaboratively (Sztein, Olson, & Ferreras, 2010). It suggests that the learning environment is disciplined and rigorous in Chinese mathematics classroom while it tends to be freer, positive and diversified in North American classrooms.

These differences correspond to the learning environment in math stories. Teachers in China play the dominant role, speaking most of the time in the class, and students are passive learners who mostly listen to the teachers. We can see this reflected in the Chinese stories, where there are not a lot of mathematical interactions between adults and children. We can see that students are silent in most stories and the adults directly point out the wrong answer and correct it rather than lead the students through activities or investigations to help them discover and correct their mistake. For example, in the story *Drinking Cola*, there is a promotion called "get one free bottle of cola by providing four empty bottles," and the problem is that "how many bottles of cola can we get if we buy 16?" The child's answer is twenty while Mom points out the correct answer is twenty-one. Actually, however, they cannot get one more cola until the extra four full bottles of cola have been drunk and returned. The child can defend his solution with the extra condition that the empties need to be returned, and the adult can also suggest to the child to think about the extra four full ones instead of telling the right answer directly. But this type of dialogue is not presented in the story. It is only the adult's point of view and solution that are presented and the child simply follows their lead.

In North America, teachers are facilitators who give students guidance and students are active learners who are able to investigate, discuss and argue; there are more interactions throughout the class between teachers and students. It is like a dialogue back and forth between teachers and students in the stories. Teachers are creating situations and opportunities for students to think and communicate mathematically; and students are more likely to be working with one another. Teachers and students are talking with each other, but teachers do not just tell them the knowledge, they ask more questions to guide

them. If we look at the story *The Doorbell Rang*, we can see that the adult just says "how can we share the cookies," but that is not the real question there; if we look at the story what is really the focus as the story unfolds is "how to represent 12 in different ways." This involves teachers facilitating discussions, creating situations, encouraging thinking differently, letting students think about themselves, but not giving the answers.

According to the analysis of math stories from the perspective of the math education system, it can be noticed that the differences in math stories do correspond to the differences in mathematics teaching and learning and the nature of mathematics and learning environments in China and North America. Chinese math stories are adult-centered where adults always pose problems and correct errors. Students are passive and do not offer their own reasoning or argumentation in Chinese stories. Adults in North American stories usually play the role of a director in leading discussions and creating situations and students are engaged in thinking and group discussions. In summary, the nature of mathematics in Chinese stories is to pose problems while North American stories focus on the elaboration of solutions/representations to develop conceptual understanding.

5.4 Research and Literature on Math Stories

As mentioned in "2.2.1 Stories in China and North America," the development of academic research and scholarly publications on math stories is more extensive in North America than in China, although in recent years the number of scholarly articles in China on math stories has grown quite quickly. From the quantitative perspective, the amount of papers and research about math stories is much larger in North America than China;

correspondingly, the number of math story books in North America is more than that of China as well.

In China, research about Chinese math stories focuses on how to use math stories to motivate students in mathematics learning (Liu, 2014; Lou, 2011). However, in addition to this, North American's research has also been advanced on how to investigate big math ideas with the help of math stories and to improve students' mathematics understanding (Gadanidis & Hughes, 2011; Murphy, 1999). It appears that the research and development of North American math stories is more developed, and looks at a wider range of issues, while Chinese research is much narrower. Many of the Chinese papers I looked at tend to repeat ideas on integrating math stories into each phase of mathematics teaching to motivate students' interest rather than explore a wide range of issues.

Because North America has a greater focus on the research and development of math stories than that of China, it likely also means that math stories are more valued in North America. Since more stories are printed and sold in North America, it is fair to expect that the production cost is lower. It is in fact the case that the price of North American math story books is lower for North American citizens than Chinese math stories for Chinese citizens.

5.5 What Makes a Good Math Story?

We have seen in this study that North American math stories are found to be better designed than Chinese math stories from the perspective of physical characteristics, plot development and mathematics development.

In terms of physical characteristics, Chinese scholars never discuss the quality of stories from this aspect while in North America, as Kurz & Bartholomew (2012) mentioned, a good math story needs to involve color illustrations, illustrations created through multiple mediums, like photos, and text and an illustration on each page. It suggests that a good math story should use different colors and meaningful pictures to illustrate the text for the sake of readers' understanding. We have seen in this study that images in North American math stories are more colorful than that of China, which would more easily attract children's attention, and the matching of the meaning of text and pictures is greater in North American stories, which would help make more contributions to motivate students and help them better understand the story. It can be seen that the authors in North America are more aware of the impact of color and pictures on the readers' interest and understanding in math story books while the authors or publishers in China haven't paid much attention to the design of pictures and the use of pictures.

In plot development, as mentioned in literature in both China and North America, a good math story is expected to have an interesting plot and interesting characters (Kurz & Bartholomew, 2012; Martinez, J. R. & Mart ńez, N. C., 2000; Zhong, 2010). However, scholars in North America also mention that the characters and plot are supposed to be well-developed. It suggests that math stories are expected to not only be interesting and attractive enough but also consider how the quality of literature would affect children's perception of people, life and the world. Math stories are supposed to be a good story in and of themselves as well as integrating important mathematics elements. We can see in the stories that no matter the location, the role and relationship of characters or the plot

twist, North American math stories are more diverse than those of Chinese stories. For example, in the Chinese story *Drinking Cola*, only two characters are described and there is little dialogue between them. The conflict of the plot happens at the end when the Mom tells the child that she can drink one more bottle. In North American story *The Doorbell Rang*, each time after sharing the cookies, the doorbell rings again, which could surprise the reader and attract their attention to guessing what would happen next. It appears that North American math stories are more thoughtful in the design of plot development so that they are more attractive and engaging for young readers.

Last but not least, in terms of mathematics development, scholars in China indicate that a good math story is able to integrate nursery rhymes, puzzles, and riddles (Chang, 2014). The Chinese math stories examined in this study use what might be classified as puzzles or riddles. We also notice that these occur near the end of the story, focus on a single solution, and the solution is led by the adult in the story. The criteria of a good story in North America put a greater emphasis on big ideas and their development within and throughout a story, and we have seen that this is indeed the case in the North American stories we examined in this study. Thus there seems to be a match between what the literature says makes a good math story and what math stories are in fact like, in both China and North America.

5.6 Writing a Better Chinese Story

A good math story is expected to have at least the following characteristics: 1) colorful; 2) direct ratio of pictures and text; 3) the matching of the meaning of text and image; 4) interesting characters and plot including multiple roles, more interactions and up and downs; 5) mathematics illustration throughout the story with various

representations. These characteristics are evident in North American stories but less evident in Chinese math stories. To illustrate how these characteristics may be integrated into a Chinese story. Below I undertake the task of rewriting one of the Chinese math stories - *Drinking Cola* in a North American style, using all of these criteria.

From the perspective of plot development, as mentioned in Chapter 4, there are only two characters Mom and Xiaotiao in *Drinking Cola*. It is the Mom who poses the mathematical problem and when Xiaotiao gives the wrong answer, it is also the Mom who tells him that his result is incorrect and gives him the hint. In the new version of this story, I include more children characters like Xiaotiao's friends or classmates so that more dialogues could be created. Then, I change the role of who poses the problem, from a single person to more characters, and the Mom does not offer solutions but facilitates children's thinking. From the aspect of mathematical development, more problems are posed and more representations (such as diagrams and tables) are presented to show the process of problem solving and lead to conceptual understanding.

The following is the revised version of *Drinking Cola*:

One day, Xiaotiao and his Mom went to the supermarket with their neighbor Mrs. Zhang and her twin daughters - Mingming and Qiqi. When they arrived at the supermarket, they found that Pepsi Cola was doing a sales promotion saying "you can get one free bottle of cola by providing four empty bottles."

"Let's make diagrams and we can see how many we can get," said Qiqi. "Ok, if we buy four bottles of cola, we can get five in total," said Xiaotiao.

4 → +1 → 5

Then, he said, “It might help to draw a table.”

“Good idea!” said Mingming.

They drew the table with three columns.

Mingming noticed that Xiaotiao wrote “1” under “Get Extra.”

Mingming said, “Oh, I don't think that we get the extra one yet. We first need to drink the cola and return the four empty bottles.”

Bought	Get Extra	Total
4	1	5

“Let’s make a new table,” said Mingming.

“OK, if we buy four full ones, we will have four empty ones, and when we return them, we can get one more full one,” said Qiqi. “So we can get five bottles of cola in total,” said Xiaotiao.

Bought	Return	Get Extra	Total
4	4	1	5

“If we buy eight full ones, we will have eight empty ones, and when we return them, we can get two more full ones,” said Xiaotiao. “Then we can drink ten bottles of cola while only paying for eight,” said Mingming.

Bought	Return	Get Extra	Total
4	4	1	5
8	8	2	10

“If we buy twelve full ones, we will have twelve empty ones and when we return them, we can get three more full ones,” said Mingming. “Thus, we can get fifteen,” said Qiqi.

Bought	Return	Get Extra	Total

4	4	1	5
8	8	2	10
12	12	3	15

"If we buy sixteen full ones, we will have sixteen empty ones and when we return them, we can get four more full ones," said Qiqi. "And we can get twenty in all!" said Xiaotiao. "Um, but we haven't drunk all the cola yet, there are four more full ones here," said Mingming. "Oh, if we drink those, we will have four more empties," said Qiqi. "Oh, then we can get another one," said Xiaotiao. "That's twenty-one!"

Bought	**Return**	**Get Extra**	**Total**
4	4	1	5
8	8	2	10
12	12	3	15
16	16	4→(1)	20(+1)

Then, they went to their mothers and showed the diagram to them.

"Oh, that's really good. I like the diagram and the tables," said Xiaotiao's mom. "And I wonder, what other ways could you use to record the information," said Mrs Zhang.

"Maybe we can use different color blocks," said Qiqi.

"Oh, let's go and try it that way," said Mingming.

Then, the children went to get some blocks.

5.7 Summary

By analyzing the findings from the perspective of math education system, we can see that the differences between China and North America identified in the literature review, in terms of the teaching and learning mathematics, the nature of mathematics and learning environment are also reflected in the differences between math stories in China and North America. Overall, comparing the similarities and differences in math stories in China and North America, it appears that Chinese math stories are less developed than North American stories. To illustrate these differences, this chapter puts forward criteria of good math stories and illustrates how to rewrite a Chinese math story to better meet these criteria. The implications of the findings will be discussed in the next chapter.

CHAPTER 6: IMPLICATIONS AND RECOMMENDATIONS

6.1 Implications

This study opens a new window into math stories in China, by showing similarities and differences in relation to math stories in North America. In the field of researching math stories, relatively few scholarly papers and research can be found in China and this study is a step towards addressing this gap. In previous math stories' research in China, scholars focus more on the importance of math stories, and the use of math stories in class. However, this study emphasizes the analysis of math stories themselves. By discussing math stories from the perspective of physical characteristics, plot development and mathematical development, this thesis points to new ways of looking at and researching Chinese math stories, creating an opportunity for other researchers to explore similar research directions.

Additionally, by discussing similarities and differences of math stories in China and North America, we can find that North American math stories are more developed than Chinese ones, which helps point out some ways Chinese math stories can improve. From the aspect of physical characteristics, Chinese story books may use more colors and pictures to make the story book more attractive for young readers, and improve the matching of pictures and the meaning of text which could help students understand the story. In plot development, Chinese math stories could draw from the North American focus on more interactions between characters and providing more opportunities for characters to solve the problem independently. Characters in Chinese stories could have more dialogues between each other and the process of communication is also a way of debating and reasoning. In the field of mathematical development, math stories in China

could pay more attention to the conceptual understanding of mathematics. By posing more problems throughout the story, all related to a theme, can help with conceptual development. And changes may be made in the type of problems, for example shifting closed ended problems to open-ended problems, thus providing more chances for students to extend their learning after reading the book. These are just a few ways that Chinese math stories may draw on the merits of North American math stories to improve the quality of math stories for mathematics learning in elementary mathematics education.

6.2 Recommendations for Future Research

All the stories analyzed in this thesis are stories in print. Currently there is a focus on providing stories digitally and also with some form of interactive content. The area of digital math stories may be the focus of future research. Continuing the comparison between Chinese and North American stories to include digital stories will add a more robust understanding of similarities and differences between China and North America. It would also be valuable to include more countries in this comparison. For example, comparing math stories in countries like Vietnam and South Korea with China might offer new insights.

Many existing studies offer advantages of using math stories in China and North America, like attracting students' attention and making the concept easier to understand, as mentioned in Literature Review. Since math stories are regarded as positive instruction tools for math education, the quality of math stories is also an important consideration. As analyzed in this study, math stories are not of the same quality. Stories may be rewritten to improve their quality. Therefore, future research about improving the quality

of math stories, such as rewriting a story, could be considered, and may include comparisons of classroom use and effect when using the original and the rewritten stories.

In the analysis chapter of this thesis, a Chinese story is rewritten to reflect some of the characters of North American stories. Repeating this process for a few more stories could lead to a study where teachers in China are engaged in comparing the original and rewritten versions and commenting on them from their perspective as mathematics educators.

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APPENDIX I

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CURRICULUM VITAE

Name: Bingqing Xu

Post-secondary Education and Degrees:
Nanjing University of Science and Technology
Nanjing, Jiangsu, China
2010-2014 B.A.

The University of Western Ontario
London, Ontario, Canada
2014-2016 M.A.

Honours and Awards:
Nanjing University of Science and Technology
University Scholarship
2010-2013

The University of Western Ontario
Joan Pederson Memorial Graduate Award
2016

Related Work Experience:
Teacher Assistant
Eureka Math – Sujie Primary School
2012-2014

Research Assistant
The University of Western Ontario
2014