Early Childhood Educ J (2016) 44:1–9
DOI 10.1007/s10643-014-0671-4

Teaching Preschoolers to Count: Effective Strategies for Achieving Early Mathematics Milestones

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Published online: 1 October 2014

Abstract Attention to early childhood mathematics instructional strategies has sharpened due to the relatively poor mathematics performance of U.S. students in comparison to students from other countries and research evidence that early mathematics skills impact later achievement. Early Childhood counting skills form the foundation for subsequent mathematics learning. In this article, we discuss the milestones of counting development and examine preschool classroom mathematics observations through the lenses of two CLASS Dimensions, Concept Development and Instructional Learning Formats. Recommendations for effective instructional strategies around counting and suggestions for incorporating mathematics instruction into storybook reading are provided.

Keywords Early childhood · Counting · Mathematics · Instructional strategies

Introduction

In recent years, interest from international researchers, teachers, and other education stakeholders in preschool mathematics instructional approaches has gained momentum. This increased interest is evidenced by comparisons of children's mathematics performance between nationalities (Geary, Bow-Thomas, Fan, and Siegler, 1993; Kovalena, 2010; Miura, Okamoto, Kim, Chang, Steere, & Favol, 1994), and evidence that early mathematics skills form the foundation of later learning (Claessens, & Engel, 2013; Manfra, Dinehart, & Sembiante, 2014). Attention to mathematics instruction in preschool to 1st grade was further sharpened by professional position statements issued in the U.S., (Bredekamp & Copple, 2009; National Council of Teachers of Mathematics, 2013) and Australia (Australian Association of Mathematics Teachers & Early Childhood Australia, 2006), which highlighted the importance of research-based, high-quality, and challenging mathematics. An emphasis on kindergarten counting and cardinality skills is also apparent in national curricula such as the Common Core State Standards (National Governor's Association, 2010) in the U. S., the Australian Curriculum (Australian Curriculum, Assessment, and Reporting Authority, n.d.), and in the National Curriculum of the United Kingdom (United Kingdom Department for Education, 2013).

Instructional approaches that capture and sustain children's interest are essential in changing the mathematics learning trajectories of preschool children. The purpose of this article is to discuss preschool mathematics instructional interactions and how they support the learning of counting skills. We will provide concrete examples of classroom interactions and research-based teaching prompts to enhance children's counting skills using developmental milestones and book reading. Specifically, we will address when children typically achieve each milestone of counting development, what each counting skill involves, and how to implement effective instructional approaches around counting and book reading.

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Background

Across the globe, policy makers and practitioners strive to improve mathematics education and learning to meet growing marketplace demands. According to Zhao (2005), there is no one approach that would be effective in all countries; rather, we must consider the contexts and out of school factors to determine appropriate approaches within each country. Despite continuing efforts to improve educational practices within an inquiry-based, constructivist approach, the mathematics performance of school-aged children in some countries, notably the U.S., remains lower than that of children in many other countries (National Center for Education Statistics TIMSS, 2011). Indeed, children of East Asian descent who often learn within a facts-based, systematic approach (Zhao, 2005) consistently outperform non-East Asian children, even when they reside in the U.S. (Lan, Legare, Ponitz, Li, & Morrison, 2011; Wang & Lin, 2009).

Differences in children's mathematics performance begin before school entry (Siegler & Mu, 2008; Wang & Lin, 2009), thus emphasizing the need to examine preschool instructional approaches, reinforce practices that lead to strong counting skills, and implement research-based instructional improvements. Effective instructional approaches are of particular importance for children from low SES backgrounds as they demonstrate lower mathematics achievement at kindergarten entry and are thus at an early disadvantage (Denton & West, 2002). Children who enter kindergarten without the necessary foundational mathematics skills do not build subsequent mathematics knowledge at the same rate as their peers who entered with stronger mathematics skills, resulting in a widening performance gap as children progress through elementary grades (Bodovsky & Farkas, 2007; Jordan, Kaplan, Ramineni, & Locuniak, 2009; Manfra, Dinehart, & Sembiante, 2014; Morgan, Farkas, & Wu, 2009). Indeed, researchers report that kindergarten entry mathematics skill levels are predictive of much later performance, not only in mathematics but also in other academic content areas including eighth grade reading achievement (Duncan et al., 2007) as well as reading and science (Claessens and Engel, 2013).

Research offers insights into which preschool mathematics skills predict later achievement and can help teachers plan and implement effective instruction during the early years. In a study of low SES preschool counting skills, Manfra, Dinehart, and Sembiante (2014) sought to determine if reciting ability (i.e. chronologically reciting the number words to 20) was as predictive of first grade mathematics achievement as counting ability (i.e., can accurately count up to twenty objects). The preschool children who could count higher numbers of objects (e.g., 20 cubes) were at a greater advantage for later mathematics achievement than the children who were not able to count as many objects and those children who could accurately recite numbers beyond their ability to count objects had an additional advantage. Such findings support the notion that counting is the premier mathematics skill that forms the foundation of later mathematics achievement.

Clements and Sarama (2009) identified counting milestones, which describe a predictable progression of early mathematics learning. The counting milestones provide a map for instructional planning by helping teachers identify children's current counting skill levels and attainable yet challenging learning goals. Movement from one milestone to the next forms each child's learning trajectory. The milestones shown in Table 1 form the framework for the teaching strategies discussed in the current article.

Table 1 Counting milestones

Milestone (when)	Math skills (what)	Teacher prompts (how)
Precounter (1-year-olds)	Identifies objects	"Where is the ball?"
	Does not associate a number word or sequence with a quantity	"Can you bring me some books?"
Reciter (2-year-olds)	Uses number words not always in the correct sequence	Models counting —"One, two, three"
	May use more words than objects or skip over words and objects	
Corresponder (3-year-olds)	Correctly uses number words in sequence	Supports child's counting - "One, two, three" while pointing to objects
	Demonstrates one-to-one correspondence with objects	"Let's touch each one while we count"
Counter (4-year-olds)	Organizes and counts objects	"How many green bears? How many blue ones?"
	Answers "how many" (cardinality)	"You have four bears. How many bears before four? What number comes after four?"
	Gives the number before and after the last number counted	
Producer (4-year-olds)	Counts out objects for a requested amount (e.g., gives nine objects when asked for nine)	"Can you give me nine blocks?"

While key, implementation of appropriate mathematics activities is only one aspect of how to build counting skills. The quality of instructional approaches during mathematics activities also plays a critical role in engaging children, building confidence and positive attitudes, and advancing children's mathematics learning trajectories. In the following sections, we will discuss the elements of quality instruction, provide scenarios of actual classroom mathematics activities, and provide teaching prompts to enhance children's conceptual development and active engagement.

Classroom Instructional Quality

At the heart of effective instruction is pedagogy – that is, the, materials, methods, and learning objectives that teachers implement to convey content knowledge (e.g., mathematics, science, literacy). The elements of pedagogy can be divided into two types: structural and process elements. Some of the structural elements of pedagogy are well known to early childhood educators and are frequently assessed (e.g., ECERS-R; Harms, Clifford, & Cryer, 2004) to improve classroom environments. Structural elements include the physical space, routines, and materials. However, attention to "process elements" is commanding stronger consideration as a marker of quality as these aspects of pedagogy are strongly related to children's learning outcomes (Howes, Burchinal, Pianta, Bryant, Early, Clifford, & Barbarin, 2008; Mashburn, Pianta, Hamre, Downer, Barbarin, Bryant, Burchinal, Early, & Howes, 2008).

Process elements "refer to…. the ways teachers implement activities and lessons, the nature and qualities of interactions between adults and children…. and the availability of certain types of activities" (Pianta, Barnett, Burchinal, & Thornburg, 2009, p. 66). Through process elements, teachers support children's mathematics conceptual development by encouraging analysis and reasoning rather than learning solely by rote and by actively engaging children using multiple modalities. Because process elements (e.g., teacher and child interactions) are more strongly related to children's academic achievement than environmental elements (e.g., room arrangement) (Mashburn, Pianta, Hamre, Downer, Barbarin, Bryant, Burchinal, Early, & Howes, 2008), we focus on instructional approaches and those levels of mathematics conceptual development that are explored during teacher and child interactions.

Process elements can be difficult to assess as teaching styles vary widely from one teacher to another. One measure of process elements, the Classroom Assessment Scoring System (CLASS; Pianta, La Paro, & Hamre, 2007), provides rubrics that address a range of teaching styles and defines quality process elements. Unlike environmental rating tools, the CLASS maintains a focus on the teacher's classroom interactions with children and on how those interactions are used to promote children's learning. The focus of this article is on two CLASS dimensions, Concept Development and Instructional Learning Formats, which provide useful lenses for teachers to think about the "how" components of teaching during counting activities.

Concept Development has a focus on how teachers use instructional activities to engage children in higher level thinking skills, such as integrating concepts and connecting them to real world experiences, and engaging children in analysis and reasoning activities. Instructional Learning Formats focuses on ways teachers structure learning opportunities, including how they incorporate learning objectives and facilitation of student engagement and interest. In this article, we will highlight effective preschool mathematics instructional approaches by providing examples from classrooms, examining interactions with a CLASS lens, and making connections to research-based pedagogy to enhance learning around counting.

Preschool Classroom Scenarios

Counting learning is evident in common scenarios of preschool mathematics instruction. The observed scenarios described in the tables below are used to illustrate methods of determining children's current milestone level and strategies used by teachers to enable children to progress to the next milestone. CLASS Concept Development and Instructional Learning Formats dimensions are used to highlight teachers' instructional practices around counting.

Concept Development and Counting

The critical elements of Concept Development include: analysis and reasoning (questions, problem solving, predictions, classification), creating (planning, producing), integration (connecting concepts, links to prior experiences) and connections to the real world (applications and relation to student lives). Instructional goals include promoting higher level rather than rote thinking skills and using strategies to expand understanding. The scenario examples contrast the types interactions that can promote higher compared to lower levels of concept development related to the counting milestones, (e.g., Reciters to Producers).

High Concept Development Interactions

Higher Conceptual Development is facilitated when children are engaged in intentional, organized problem solving and teachers include activities and questions that support

Table 2 High concept scenarios: current milestones and prompts to support the next level

Scenario	Milestone	Positive components of the activity	Prompts to progress to the next milestone
1. Teacher, "We need 10 bugs in the jar. How many are in there?" Child counts, "Nine". Teacher, "How many do we add to make 10?" Child, "One". Teacher, "Now count the bugs again to make sure"	Corresponder milestone (i.e., correctly use number words in sequence and connect each number word to one object in order) Counter milestone (i.e., can answer how many)	The teacher played a key role in setting up a context and using 'how many' and 'which one' questions to scaffold and capture children's thinking and reasoning	Teacher: "Tell us how many bugs you want in the jar. Will you count them and tell us how many are in the jar?" Determining the quantity to construct and compare moves the child beyond counter to producer
2. The child works with Unifix cubes. Teacher, "What do you need here? Child, "One". Teacher, "Can you count this row for me?" Child counts one to five. Teacher, "How many go in the next row? Child, "Six"	Corresponder milestone (i.e., correctly use number words in sequence and connect each number word to one object in order) Counter milestone (i.e., can answer how many)	Children count bugs, Unifix cubes, and blocks to provide examples of how counting is linked to reaching the correspondence milestone	Teacher: "Will you make another row and tell us how many you put in your row?" Providing an opportunity to determine the quantity and to construct and compare moves beyond just counter to producer

Table 3 Low concept scenarios: current milestones and prompts to support the next level

Scenario	Milestone	Positive components of the activity	Prompts to progress to the next milestone
3. The teacher removes toy fish from a jar one by one and the class counts out loud from 1 to 20. She holds up the numeral 20 saying, "This is what the number 20 looks like." The connection between the word 20 and the symbol is still abstract	Counter milestone (i.e., can answer how many)	The use of fish and connecting the one to one correspondence to the count sequence	Teacher: "Let's make a group of twenty fish and put one fish in each egg cup." Children place fish into two sets of ten egg carton cups and count again. The move from counter to producer requires that children keep track of what has been counted
4. The teacher asks, "How many people can be in this area?" Child responds, "Three". Teacher, "You make four. You can't play here"	Reciter	The child is being asked to recognize a quantity	Teacher: "How would you know if there was room for you in the center? Let's point to each child in the center and count." Modeling corresponding helps the child hear the number sequence and progress from reciter to corresponder

children's reasoning and use of multiple skills as illustrated in Table 2.

Low Concept Development Interactions

In contrast, during lower level interactions teachers primarily address Reciter skills by having children rote count to 20 or mimic or recite the numerals on a calendar as illustrated in Table 3.

In the Concept Development and Counting section, we reviewed examples of mathematics events that take place in early childhood classrooms. The scenarios illustrated levels of children's conceptual development and the role of the teacher in facilitating the progression to the next milestone. In the next section, we examine additional classroom mathematics events and relate the observed teaching strategies to the Instructional Learning Formats dimension of the CLASS.

Instructional Learning Formats and Counting

The second aspect of instructional quality is Instructional Learning Formats. The goals are to maximize "interest, engagement, and ability" to learn from instruction and activities. The scenario examples contrast the types interactions that can promote higher compared to lower levels of Instructional Learning Formats.

High Instructional Learning Format Interactions

Classroom activities with higher levels of Instructional Learning Formats are environments where the teacher facilitates child engagement, implements multiple modalities (e.g., visual aids, movement, and sound), provides clearly stated learning objectives, and works to maintain high levels of engagement in activities as illustrated in Table 4.

Table 4 High instructional learning format scenarios: current milestones and prompts to support the next level

Scenario	Milestone	Positive components of the activity	Prompts to progress to the next milestone
5. Teacher," How many holes are in your strip of wood?" Each child counts and responds. Teacher, "How many candles do you need? Which one of you has the most? Which one has the least?"	Corresponder and counter	By using strips of varied totals the children went beyond counting to make comparisons and to use mathematical language of most and least	Teacher: "Choose a strip and tell us the number of holes. How is your strip that alike or different than the others?" Giving a choice of strips provides a reason to extend the counting skills beyond 10 Comparing reinforces the ideas of more and less
6. The teacher holds up a numeral 5 and tells the children to get that many fishing poles (small pretzel sticks). The teacher holds up a numeral 10 and asks the children to put that many goldfish crackers on their plate. She instructs them to dip their five fishing poles into icing to 'catch' 10 goldfish	Counters and advancing to the producer	The written numeral represents how many fishing poles and fish. The children produce a larger set when they 'catch' ten fish. Dipping each pole into icing and catching the fish reinforces one-to-one correspondence	Teacher: "You have caught and eaten three fish (point to their mouth) three, and now lets touch and count the remaining fish, four, five, six…. This activity guides the development of counting on from a target number

Table 5 Low instructional learning format scenarios: current milestones and prompts to support the next level

Scenario	Milestone	Positive components of the activity	Prompts to progress to the next milestone
7. A child asks, " Can I have an eight?" Teacher, "Show me which one is an eight." She places numeral papers on the floor. The child picks up the eight. Teacher, "Good job!"	Reciter	Introducing numerals related to the counting sequence	Teacher: "Touch and count my fingers. How many am I holding up? Can you hold up eight fingers? How many more would you need to have ten?" The questions engage children in corresponding and counting and moves them beyond just reciting
8. A child counts stickers as he takes them from an envelope. The teacher says, "You have 18"	Counter	Providing materials for children to manipulate and count	Teacher: How many stickers have you counted so far? How many more would you need to have twenty?" The questions engage the child in problem solving moves them to producer

Low Instructional Learning Format Interactions

Interactions on the lower level of Instructional Learning Formats often focus on Reciter skills and less on using questions to elicit or scaffold Producer level responses as illustrated in Table 5.

The classroom scenarios illustrate highly effective and less effective Instructional Learning Formats to enhance counting skills. Teachers utilize different materials to capture students' interests but do not always use effective questioning and maintain active student engagement in the activities. By using the CLASS Instructional Learning Formats lens, teachers can develop more effective interaction skills, make the best use of children's interest, and engage children in mathematics lessons and activities.

Summary of the Scenarios

The provided scenarios are accompanied by suggested strategies to foster progression along the learning trajectories of counting. In the following section, we provide suggestions to maximize instructional time by incorporating quality mathematics instruction during shared storybook reading. We will discuss effective questioning during book reading to attain counting milestones and present teaching strategies to achieve higher level CLASS Concept Development and Instructional Learning Formats.

Purposeful Mathematics Activities through Literature

Literacy instruction, including book reading, is a typical part of preschool classroom daily routines and is often allotted more time than mathematics instruction when multiple curricular demands conflict (Ginsburg, Lee, & Boyd, 2008; Phillips, Gormley, & Lowenstein, 2009) yet literacy and mathematics instruction need not be mutually exclusive. Indeed, linguistic (Kleemans, Peeters, Segers & Verhoeven, 2012; Sarama, Lange, Clements, & Wolfe, 2011) and literacy (Purpura, Hume, Sims, & Lonigan,

Table 6 Mathematics Concepts and Books

Core concepts	Related skills	Age range- Sarama and Clements (2009)	Books
Recognition of number /subitizing	Accurately determines quantity up to three or four items without counting (Geary, 2000) Numbers are used in many ways Quantity is an attribute of sets Numbers are used to name quantities Quantities of small collections can be perceived without counting	1–2 years Names groups of one to two 3 years Makes small collections	*1,2,3 to the Zoo*—Carle *Every buddy counts*—Murphy and Dunbar *Pete the cat and his four groovy buttons*—Dean and Litwin *Ten black dots*—Crews *What comes in 2s, 3s and 4s?*—Aker
Counting	A system for enumeration of small sets (Geary, 2000) Counting can be used to find "how many" Counting has rules	1 year Chants some number words 2 years Verbally counts (not necessarily in the correct order) 3 years Verbally counts to ten. Keeps one-to-one correspondence between counting and objects	*A frog in the bog*—Wilson *How many snails?*—Giganti *One duck stuck*—root *One, two skip a few*—Arenson *Rainbow fish counting*—Pfister
Simple arithmetic	Sensitivity to increases and decreases (Geary, 2000) Can change sets by adding and taking some away Can compare sets using numbers and order by more than, less than and equal to Quantity can be decomposed into equal or unequal parts; parts can be composed to form the whole	1 year Begins to recognize more and less 2–3 years Nonverbally adds and subtract very small collections	*12 Ways to get to 11*—Merriam *Each orange had 8 slices*—Giganti and Crews *Elevator magic*—Murphy *Monster musical chairs*—Murphy *More, fewer, less*—Hoban *One is a snail, ten is a crab*—Sayre and Sayre

2011) skills are related to numeracy conceptual development. The combination of book talks and instructional learning formats provides an effective forum for mathematics facilitation (Baroody & Seo, 2000), increasing the variation in modalities and materials, increasing student interest, and targeting clear learning objectives.

Counting concepts can be easily integrated into literacy activities through intentional selection of age appropriate and engaging books. Instructional practices that incorporate process elements, such as Concept Development and Instructional Learning Formats, into book reading can build higher level thinking skills and sustain children's attention by engaging them in problem solving activities. These practices in turn can provide opportunities for children to practice Reciting, Corresponding, and Counting skills on the way to becoming Producers.

The key to effective use of any book starts with a book talk to provide advance organizers (Ausubel, 1960). Instruction begins by looking through the book with the children and encouraging them to talk about the pictures, make predictions of what will happen in the story, and to connect their own experiences to story elements. As part of Instructional Learning Formats, learning objectives can be clarified through advanced organizers (e.g., "We are going to read a book about a cat with four buttons on his shirt and count them each time one falls off.") and summary statements, (e.g., "So, we just read about Pete's buttons. Each time one fell off he had fewer buttons. We counted his buttons. Let's count again.") so that the whole group of children can attend to the mathematical language and the instructional purpose of the story. In Table 6, we provide a list of books and describe how they can be connected to core mathematics concepts.

During story activities, instructional strategies can be used to support children's understanding of counting concepts. For example, Concept Development strategies include reasoning questions, such as, "Why are those numbers in the picture?" "What patterns did you see?" "Tell me why you think he had more?" Teachers can use the counting sequence, ask children for their ideas on how counting can solve the story's dilemma, and use frequent pauses to engage children in conversations about their

Table 7 Alignment of children's book reading with mathematics milestones

Milestone	*Teacher* prompt	*Ten black dots* prompts	*Rainbow fish* counting prompts
Precounter	Call attention to quantity without counting. Focus on more, less, and same	Teacher: "See the one black dot. See the three black dots. Which page has more dots?"	Teacher: "See the whales, put your fingers on them. Are there more whales than crabs?"
Reciter	List counting words in the correct order	Teacher: "Say them with me one, two, three dots"	Teacher: "Count with me. One, two, three, four, five dolphins"
Corresponder	Connect counting words in one to one correspondence with items	Teacher: "Let's count the black dots. You point as we count together"	Teacher: "Put your fingers on the snails as we count them together"
Counter	Support accurate counting by organizing objects in a pattern and counting left to right. Consistently ask how many all together?	Teacher: "Can you touch the dots and count them? How many are there all together?	Teacher: I see some seals. Can you count them and tell how many you see altogether?
Producer	Provide items for child to create sets as directed Ensure that there is the same number as the items in the book	Teacher: "Here are some black disks. Can you make a group of nine disks? How do you know you have nine?"	Teacher: "Let's use fish crackers to make the same amount of rainbow fish on this page. How can we make sure we have the same number as the page?"

predictions ("How did it really happen?" "Why was our prediction right?"). Examples of how to support counting skills at each milestone are illustrated in Table 7.

During book reading, story characters and their dilemmas can be used to brainstorm solutions and for relating to personal experiences. Strategies involving Instructional Learning Formats can be used to intentionally include movement, language, and hands-on activities to engage children in applying their counting skills to the story. Focusing children's attention by pointing out numbers embedded in pictures, having children use tokens to measure lengths or heights (e.g., Chicka, Chicka 1, 2, 3 math activities; Martin, 2004), and discussing the definitions of words used in a story (e.g., "How big is a gazillion?") can provide opportunities for learning and connecting learning to mathematic objectives. Finally, teachers' knowledge of the counting milestones can inform book selection that meets the children's developmental needs.

Conclusion

Preschool children are quite capable of mathematics learning and, in fact, choose to engage in mathematical thinking during everyday activities (NAEYC & NCTM, 2010). Research supports that the mathematics knowledge children bring to kindergarten is related to their mathematics learning in later years (National Math Panel, 2008), and that children from lower-income backgrounds who are at risk of achievement gaps can learn mathematics skills when they engage in high-quality early childhood experiences. Mathematics events, such as determining how many short blocks equal the length of a longer block or counting friends in housekeeping, are developmentally appropriate, take place naturally in children's play settings, and are connected to children's own life experiences. Together, these events meet recommendations for high-quality early childhood practices (Copple & Bredekamp, 2009).

Ultimately, mathematics talk is key to children's development (Klibanoff, Levine, Huttenlocher, Vasilyeva & Hedges, 2006). Teacher strategies of using why and how questions, problem solving in guided learning, and center play activities are vital teacher – student interactions that build children's understanding of mathematics. Teachers who make connections to past learning, link concepts, and facilitate active engagement in classroom activities support higher levels of Conceptual Development as defined by the CLASS.

In the above sections, we provided suggestions for teacher questioning strategies that promote higher level counting skills. We also provided strategies for scaffolding counting skills during storybook reading with a list of age appropriate books to help children progress from Reciter to Producer and suggested the use of the CLASS as a tool for teachers to refine mathematics interactions. As illustrated in the classroom scenarios, instructional strategies to support counting skill development need not require major shifts in current practices. Simple changes in mathematics interactions that are already taking place can enable children to show their thinking skills around Counting and enable teachers to see how children are progressing from Reciter to Producer. Through use of the Counting Milestones, teachers can identify children's current skill levels and determine appropriate learning goals to promote counting learning trajectories.

As nations work to develop and refine early learning guidelines or standards to ensure that all children enter

school ready to succeed, attention to mathematics as a core area has increased. Early learning standards have clarified the mathematics concepts to be targeted by age or grade, the behavioral indicators reflecting children's learning, and the activities with which teachers, parents, and other caregivers can engage children to increase mathematics learning. High-quality pre-service educational and in-service professional development opportunities to enhance instructional approaches around mathematics are key in the efforts to improve early mathematics learning outcomes.

Early childhood teachers have an invaluable opportunity to arm themselves with research-based instructional approaches to improve children's mathematics outcomes. Teachers can make use of the knowledge gained through the mathematics milestones to enhance foundational counting skills through intentional instruction during everyday activities. These efforts guided by international professional organizations highlight the importance of key content and pedagogy that will prepare young children for the mathematics they will need for future academic success.

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