Picture books stimulate the learning of mathematics

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IN THIS ARTICLE WE DESCRIBE our experiences using picture books to provide young children (five- to six-year-olds) with a learning environment where they can explore and extend preliminary notions of mathematics-related concepts, without being taught these concepts explicitly. We gained these experiences in the PICO-ma project, which aimed to generate more knowledge about the effect of picture books on young children's learning of mathematics. The project's goal is to investigate how picture books can contribute to the development of mathematical concepts in young children, and how the actions of the teacher can strengthen the characteristics of picture books that support learning. The reading sessions described in this article were not intended to be mathematics 'lessons'. Instead, the reading sessions were intended to tell the children a pleasant story and, at the same time, give them something to think about. Based on our research we provide reasons for using picture books to develop mathematical thinking, and include recommendations for practitioners interested in using picture books for mathematics learning.

Introduction

THE USE OF PICTURE BOOKS to support children's learning, and the research that investigates this, generally focuses on learning related to language development, including oral language skills and early literacy concepts (Blok, 1999). However, since the late 1980s, linking mathematics instruction to children's literature has become increasingly popular (Clyne & Griffiths, 1991; Doig, 1987, 1989; Haury, 2001). During that period, several books were released that either provided examples of teachers who used children's literature (see Whittaker, 1986) in mathematics teaching, or provided teachers with guidelines on how to use picture books—and children's literature in general—in their mathematics lessons. This popularity has extended to some authors' websites, where parents are provided with suggestions for using storybooks for educational purposes, and not just mathematics (see Kehoe, n.d.).

Children learn mathematics from meaningful contexts, and teaching should build on the informal knowledge children have acquired both before starting school and outside school hours. This view, of the supportive role of intuitive and informal knowledge when learning mathematics and the importance of a meaningful context in establishing mathematical thinking (Donaldson, 1979; Hughes, 1986), is widely accepted in current theories on learning and teaching mathematics (Bransford, Brown & Cocking, 2000). Or, as one first year of school teacher, Sue, said: 'With the little ones I think that books are great … it engages them straight away, so … that's good' (Doig, 2008). Learning mathematics by starting with a context that makes sense to children also forms one of the founding principles of Realistic Mathematics Education (RME), the Dutch approach to mathematics education (see Van den Heuvel-Panhuizen, 2001). RME sees mathematics as an integral part of human experience, which means that it can also be seen as an integral part of the stories told in picture books. For that reason we believe the use of picture books is well-suited to this reformed approach to mathematics education.

What we want to show is that good, but ordinary, picture books—in the sense that they are not written to teach mathematics—have the power to get children thinking mathematically. Through reading picture

books, children encounter novel images or actions that linger in their minds, which they can combine with previous experiences, and on which they can build new thoughts and understandings. This means that the pictures and the situations in the stories can function as 'cognitive hooks' for the children (Lovitt & Clarke, 1992) that trigger and form a foundation for their mathematical development. Some good insight into the power of picture books was acquired in a study by Van den Heuvel-Panhuizen and Van den Boogaard (2008), which showed that mathematical thinking can be invoked in young children when they are read a picture book. The findings of this study, conducted as part of the *PIcture book and COncept development in mathematics (PICOma)* project, support the idea that reading children picture books without explicit instruction or prompting has lots of potential for mathematically engaging children. This perspective was also taken in the *PICOma* study reported in the present article.

Method

To show the range of possibilities that picture books hold for giving young children access to mathematics—through offering them a source of experience for further concept development—we look beyond the more familiar domain of numbers and include here three examples from three separate mathematical domains that are less likely to be touched upon with young children. The first example deals with geometry, in particular the cross-sections of objects and shapes. The second example is about data handling, where a time-length graph and a time-weight graph are used to express growth. The third example addresses measurement, and includes issues such as scale and ratio, and measuring objects that are curved. All these topics are recognisable as content that usually only appears in a traditional mathematics curriculum in the later years of schooling—often not before secondary school. The power of picture books is that they can give children an informal entry to these topics early on.

The three examples were collected as part of the *PICOma* project, and come from reading sessions with picture books in a kindergarten/K2 class (five- and six-year-olds). In the Netherlands, kindergarten is part of primary school and spans a two-year period, for children aged four to six years. These kindergarten years serve as a transition from home to the commencement of more formal schooling in the classes of primary school. This means that the children involved in the reading sessions—the four girls, B, I, J and M, and the two boys, K and T—had not yet received any formal reading or mathematics instruction. The children were not able to read for themselves. The reading sessions were held at an inner-city school in a large city in the Netherlands. The population of this school mainly consists of immigrant children whose language development is behind that expected of other children their age. As a result of this background, the mean age of the children involved (6 years, 3months) is somewhat above average. The children's teacher read the picture books to her children, as was prescribed in the project reading guidelines. The books were new to the children when the reading sessions took place (in a gym) and the sessions were video-recorded.

Example one: First steps in geometry

Young children understand more and more of the world as they move through space, and as they interact with the objects in that space, experiencing how the world works (Van den Heuvel-Panhuizen & Buys, 2008). The classroom can offer an environment where experiences can be gained, and can help expand spatial thinking further. However, this does not mean that the process only starts when formal education starts. As emphasised by Clements (2004a, p. 38), '[T]his early knowledge can be supported by experiences in homes, day-care settings, and pre-kindergartens so that all children build a strong foundation of geometric and spatial thinking.'

Clements and his colleagues also emphasise that, in early childhood, geometry and spatial reasoning form the foundation for much of the mathematics learning, as well as other subjects. Among other things, they mention that 'geometric shapes can be described, analysed, transformed and composed, and decomposed into other shapes'; that 'mathematics can be used to specify precisely directions, routes and locations in the world'; that 'mental images can be used to represent and manipulate shapes, directions and locations'; and that 'objects can be represented from different points of view' (Clements, 2004a, p. 39).

It is also during early childhood that children continue to construct mental images of shapes, including geometric shapes. It is known that kindergarten children (four- to six-year-olds who are not yet in grade classes) and even pre-kindergarten children show the ability to slide, turn and flip shapes mentally in certain settings, and they can also generate and inspect mental images ('Think of a square. What do you see?'). They can also transform these mental shapes in certain ways ('Think of a square cut down the middle. What do you have?'). However, what is important is that they are provided with opportunities to develop these abilities (Clements, 2004a).

The picture book

The picture book read to the children was *O, nee! Pop in de wc ... [Oh, no! Doll in the toilet …]* (Huijsing, 2006). The book tells the story of a girl named Nina

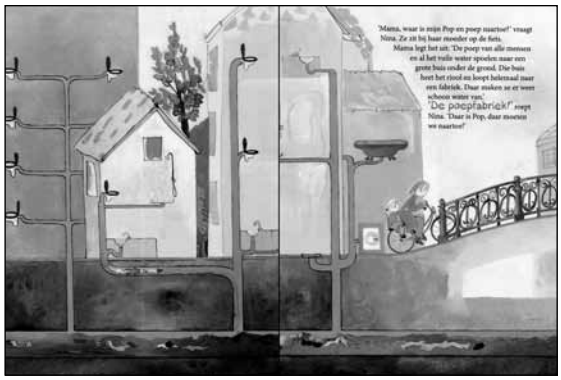
who loses her doll by accidentally flushing it down the toilet. Together with her mother, Nina goes out to find her doll. Fortunately, Nina's doll is saved by a worker at the sewage plant.

At one point in the book, the internal structure of the houses is visible—which means that the flow of the drains and their content can be seen in the picture. The houses are more or less cut in half, so that the children are presented with a cross-section. This cross-sectional view is partially continued on the following pages, when the girl and her mother go along the road that takes them to the sewage plant. Here, the children are given a split view. The upper part of the picture shows the normal view and the lower part shows cross-sections of the soil and the sewer pipe. Through this special view the children can see where the doll is.

Snapshot from the reading session

The teacher read and discussed the book up to page 8. Then, she examined pages 9 and 10 (see Figure 1) with a look of amazement on her face. On the left-hand page, we can see that the doll is in the drain under the sink. On the right-hand page, Nina and her mother are already on the bike, going to search for the doll.

Figure 1 Pages 9 and 10 of the book *O, nee! Pop in de wc … [Oh, no! Doll in the toilet …]* (Huijsing, 2006)



[Translation of the text:

'Mama, where did my doll and the poo go?' Nina asks. She is with her mother on the bike. Mama explains: 'The poo of all the people and all the dirty water washes to a big pipe underground. That pipe is called the sewer and runs all the way to a plant. There they turn it into clean water again.' 'The poo plant!' Nina cries. 'That is where Doll is, we should go there!']

Before reading the text aloud, the teacher pretended not to understand what was shown in the picture. She waited for the children's reactions. The following is a transcript of part of the reading session:

B:	There is water in here. [B points to the big sewage pipe.] [Next, she points to the doll in the drain.]
Teacher:	Where is Doll?
B and I:	Here. [B and I point to the doll in the drain.]
B:	Goes on like this. [B points out the route that the doll will go on through the drain and the sewer.]
I:	Goes to the other water …
K:	All toilets. [K points to the toilets on page 9.]
Teacher:	Where, then, do you think Nina lives?
K:	[K moves his finger from the doll through the drain up to the toilet in Nina's house.] Through this toilet she went.
I:	Here. [I indicates the route of the doll from the toilet to the sewage pipe.]
Teacher:	Where is Nina's toilet? [M and K point to Nina's toilet]
Teacher:	There, eh?
K:	And then she goes like this ... [K points out the route.]
Teacher:	And then she goes this way, eh? [Teacher points out the route once again.]
Teacher:	And where are Nina and mum? [B and I point to them.]
I:	They should go that way. [I points to the left.]
K:	Because they see it. [K points to the doll.]
B:	They do not see it. They look and then she is not there. Because she is underground.
K:	She is in the sewer.
Teacher:	You say, 'Mum and Nina are not searching well, because Doll is still here.' But B says, 'Yes, they do not know that, because it is underground.'
B:	Then they should remove the stones.
Teacher:	Can they see where Doll is, then?
I:	Miss, the doll is here. [I points to the doll.]
Teacher:	We see that all right. But do mum and Nina see that?
All:	No.
Teacher:	Because B already said it; it is underground.

Reflection

By holding back at first, the teacher gave the children the opportunity to examine the picture themselves. The picture encouraged the children to look for the doll and to indicate the route it would take. The teacher extended this quality of the picture by asking where Nina lived. The children spontaneously pointed to the doll and showed its route through the pipes. This behaviour indicated that the children understood what they were seeing. The transparent houses and pipes did not seem to surprise the children. Although it is likely that it was the first time they had seen such a cross-section, they seemed to take this view as something self-evident to them.

When the teacher asked the question of whether Nina and her mother could see the doll, one of the children (B) seemed to convince the other children of the fact that the doll was visible to the children, yet not to the characters in the book. The reactions from the children revealed that some of them could already cope with different views in one picture. The fact that others were not yet able to see the different views is not problematic —the children were being exposed to new ideas, and, as the teacher interviewed by Doig (2008) suggested, all the children 'may not be able to [solve the problem] but it is important that they be able to see somebody who's [understanding] this, and [think] maybe I can get that too.'

Example two: First steps in data handling

Data handling, or data analysis, is a mathematical domain not often dealt with in the grade classes of primary school, let alone during the kindergarten years (when children are four to six years old). Only recently has it been recognised that it is important for children to build up data sense from an early age (Perry & Dockett, 2002). As was shown by Curcio and Folkson (1996), children's informal comparing, classifying and counting activities can provide the mathematical beginnings for developing young learners' understanding of data, analysis of data, and statistics more generally. Moreover, they can compare parts of the data, and make statements about the data as a whole (see Clements, 2004b). Further, by posing questions and gathering data about themselves and their surroundings, children can learn to represent this data.

Not much information can be found in the research literature on young children's ability to read graphs. For example, the framework for statistical thinking developed by Jones et al. (2000) starts with describing data and finishes with analysing and interpreting data. It outlines recognising patterns and trends, and making inferences and predictions, as the highest level of statistical thinking. When and how young children can develop their ability to read graphs is unclear—since they mostly do not read newspapers, where can they come across graphs? Fortunately, picture books can offer children access to the world of data representation.

The picture book

The picture book read to the children was *De verrassing [The surprise]* (Van Ommen, 2003). This is a book without text; the pictures alone tell the story. The lead character is a white, woolly sheep. We see the sheep weighing and measuring the thickness of its fleece. On its motor scooter, the sheep goes to a shop to buy some paint. Back home, the sheep dyes, washes, dries and shears its fleece. Dressed in a jumper, the sheep takes its wool to a poodle for spinning. The sheep knits a jumper from the spun wool, wraps it in a tablecloth, and gives it to a giraffe as a present. The sheep is rewarded for this nice gesture with a kiss from the giraffe. At some point, a line plot is depicted. Not many kindergarten teachers would include line plots in their curriculum but, as we will show, it turns out that children are quite able to read this graph. They can give meaning to it and even tell how it is built up.

Snapshots from the reading session

On every page, the teacher asked the children to tell the story that was in the picture. When she arrived on page 3 (see Figure 2), the children discussed what the sheep was doing.

Figure 2. Page 3 of the book *De verrassing* [*The surprise*] (Van Ommen, 2003)

The picture shows the sheep holding a red pencil and a ruler. On the wall there is a graph. The upper upward line on the graph is blue, the lower one is red.

I: There he is doing something.

Teacher: Yes, what is he doing now, the sheep?

I: I don't know what that is …
Oh, yes, how long he is, with that metre stick.

Teacher: Yes, it looks like a metre stick, eh?

J: No, so many days he puts down a little cross.

Teacher: Where, then, does he put a little cross?
[J points to the piece of paper on the wall.]

Teacher: Oh, yes, here he has a sheet of paper, eh?

I: But there is the date.
[I points to the graph.]

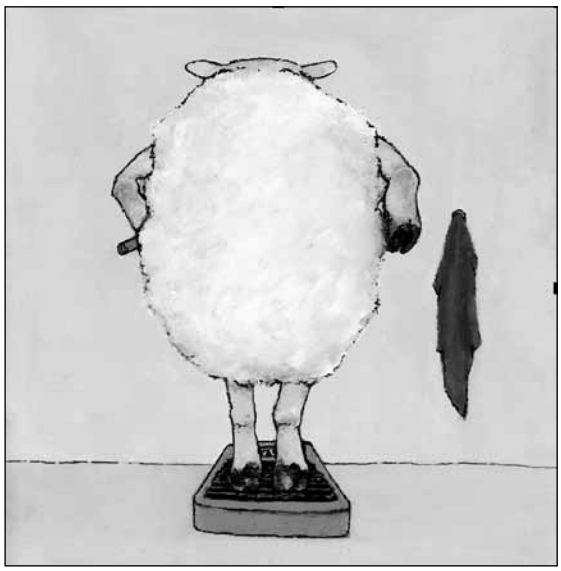
Then the resemblance between the piece of paper on the wall and a bulletin board is discussed. After this, the teacher goes on about the graph.

Teacher: Someone said, 'These are the days.'
Who said that?
That was you, eh, I?
Why do you think so?

I: Because there are little squares.

In this way, the teacher 'read' the whole book with the children. After that, she went through the book again while asking more questions. On page 1 (see Figure 3) it was discussed that the sheep was weighing itself. While standing on the scale, the sheep holds a blue pencil.

Figure 3. Page 1 of the book ***De verrassing*** [***The surprise***] (Van Ommen, 2003)



On page 3, the teacher came back to that pencil.

Teacher: Now he does something else with the blue pencil.
He was weighing himself…
and then he put a little line here.
[The teacher points to the start of the blue line.]

I: I know.
He had this one ...
[I points to the ruler.]
He was a little under ...
he was a little slim ...
and now he has got a bit fatter.

Teacher: Yes. And how can you tell from this picture that he has got fatter?
What happens to the line?

I: Because he goes much higher with the line.
[I follows the line with her finger.]

Teacher: Yes, the line moves up all the time.

Reflection

Without being told, the children understood that the sheep was measuring and keeping track of the results. Moreover, their reactions revealed that they had an idea of what the function of the ruler was—to measure the length of something. When they saw the chart, the children assumed that the sheep was doing the measurement every day, and that it was marking the result on the chart. The children seemed to have a notion of the use of a chart. They even understood that the upward-going line represented an increase. This was true for the thickness of the sheep's fleece and the weight of the sheep. The problem of how both can be read from one graph was not discussed.

In any case, what this example showed us was that picture book authors can open our eyes to what children understand. In regular curriculum materials for kindergarten (so for four- to six-year-old children), one will not often see line graphs. However, picture book authors do not hold to the standards—they do not even know those standards—so they simply include a graph when it fits the story, with surprising consequences. Therefore, the book was not only about a surprise—it had a surprise for us as well.

Example three: First steps in measurement

Like geometry, measurement is a way to gain an understanding of the physical world we live in. It is one of the main real-world applications of mathematics (Clements & Stephan, 2004). Children's understanding of measurement has its roots in the years before kindergarten—so when they are younger than four. During their kindergarten years children become less dependent on perceptual cues when comparing particular amounts.

As Clements and Stephan (2004) explain, this means they recognise that two identical balls of clay—even when one is transformed into a sausage-like shape—still have the same amount of clay in each.

In kindergarten, measuring (whether done consciously or not) is a natural element of many activities. For example, it takes place when children are playing in the home corner and are looking for a blanket big enough in size to cover a doll's bed. In addition to these spontaneous activities, planned measuring activities can be organised in which the children have to think up handy and honest comparison strategies, and gain experience with repeating a particular unit when measuring length (Van den Heuvel-Panhuizen & Buys, 2008).

The picture book

The story of *De prinses met de lange haren* [*The princess with the long hair*] (Van Haeringen, 1999) starts with the birth of a princess. The hair of the princess grows very fast; lackeys have to carry the hair, which is washed in a swimming pool by nine ladies. The poor princess is not able to play because of her very long hair, but her father forbids her to cut it. When the princess reaches marriageable age, a strong man from the circus is hired to carry the hair in two suitcases. The king wants the princess to marry a wealthy man. However, the princess refuses, and escapes to have a joyful life with the strongman.

Snapshots from the reading session

The front cover (see Figure 4) was shown to the children.

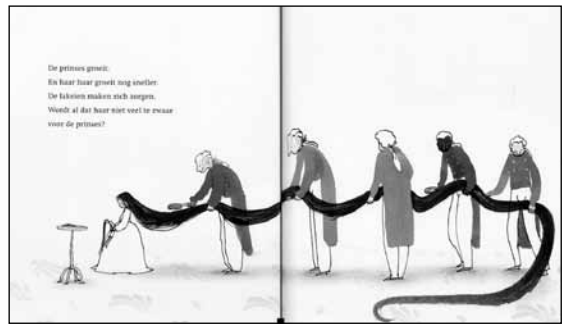
Figure 4. Front and back cover of the book *De prinses met de lange haren*. [***The princess with the long hai***r] (Van Haeringen, 1999)

The children were given the opportunity to respond to the picture on the cover. The title was not yet read aloud to them.

J:	The long hair girl.
Teacher:	So you already think you know the title!
B:	It looks like way too long hair.
J:	Yes, it is long, just look – hey hey! [J follows the spiral of hair with her finger.]
K:	Like this, like this, like this. [K follows the spiral of hair with his finger, starting at the head of the princess.]
J:	All the way to here. [J points to the back cover of the book.]
Teacher:	Yes, you are right. Shall I open it like this? Then you are able to see it well. [The teacher spreads out the book so that the back and the front cover are next to each other.]
All:	Wow!
Teacher:	Long, hey?
J:	Goes like this. [J follows the hair with her finger, starting at the end of the hair. Every time she meets the princess, she goes up with her finger to the princess's head and then back again to continue.]
T:	Then she always falls, then she will always stumble over it.
Teacher:	Did you all hear what T just said?

Later, pages 3 and 4 (see Figure 5) were shown to the children.

Figure 5. Pages 3 and 4 of the book *De prinses met de lange haren*. [***The princess with the long hair***] (Van Haeringen, 1999)



The teacher read the text. Then she drew their attention to the part of the text that says: 'The princess grows. And her hair grows even faster.' The teacher asked how one could tell this.

Teacher: In the book it says her hair grows even faster than the princess.
How can one tell?

I: Because her hair is super long now.

Teacher: And the princess?

I: Small.

Teacher: She is not that tall, hey?

J: She was a baby, right?
Now her hair is grown and then she had got long hair.

Teacher: She has got long hair, yes.

I: Five men got to hold it.
[I raises four fingers.]
[The teacher asks the children to speak one by one, for they all speak at the same time.]

Teacher: The princess has grown just a bit, right?
[The teacher points to the princess from top to toe.]

K: Up till here.
[K points to a part of the hair that has the same length as the princess.]

B: She is this big.
[B walks to the book and measures the height of the princess with the tips of her index fingers.]
One, two, three, four, five, six, seven.

Teacher: Seven what?

All: Seven metres!

Teacher: Seven metres?
So you have fingers of one metre?

B: No!

K: [K measures seven times his fingertip on the princess's hair]
Up till here.

Teacher: So she has grown seven fingers, that is how tall she is.
[In the meantime J tries to measure the whole length of the hair with her fingertip.]

Teacher: You have very thin fingers.
Shall I go and see with my fingers how tall she is?
[The teacher measures the princess with her index fingers.]

All: One, two, three, four, five.

Teacher: With me she is just five fingers tall.

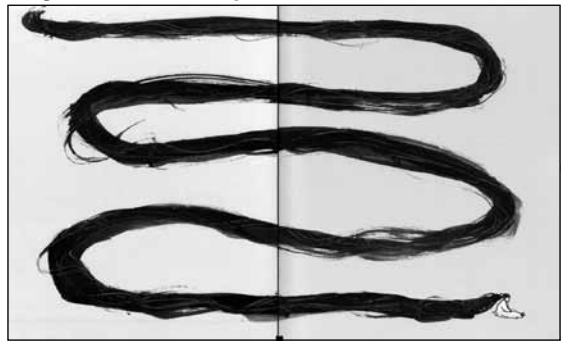
I: Because you have thick fingers.

Teacher: Yes, my fingers are much thicker.

J: Look at my little finger.
[J measures the princess with the tip of her little finger.]
One, two …

At the end of the reading session the endpapers (see Figure 6) were shown to the children. The teacher asked how long the children thought the hair would be in real life.

Figure 6. Endpapers at the back of the book *De prinses met de lange haren*. [***The princess with the long hair***] (Van Haeringen, 1999)



Teacher: And if you look at her hair, here her hair is very long.
[The teacher points to the zigzag of hair.]
How long do you think it is in real life?

I: Very long.

B: This long.
[B stands up and walks the pattern of the princess's hair in an empty space of the gym.]

Reflection

The way the concept of measurement appears in this picture book is quite different from the activities found in textbooks and instructional guides. The picture book does not reflect a smooth building-up of the different aspects of measuring—starting with easy situations and gradually including more complex situations. Here, all the difficulties are presented at once, and come all mixed together. For example, dealing with 'How long is something that is bent and how can you measure this?' before the children have become familiar with measuring straight lines; and dealing with growth at different speeds (the hair and the girl) before the children have, we assume, a good understanding of the growth of one attribute.

Moreover, when discussing the length of the hair, the children had different ways of expressing the length, the amount of time it takes to follow the hair with your finger or to walk the length in the gym, the number of fingertips the hair measures, and the number of book pages the hair measures.

Stephan and Clements (2003) claim that there are two important aspects to measurement: 'identifying a unit of measure and subdividing (mentally and physically) the object by that unit and … placing that unit end to end (iterating) along-side the object being measured' (p. 3). It is clear that some of the children in this group were spontaneously measuring by this definition. Further, the fact that the issue of unit size as related to the number of iterations was raised by the children suggests a mature understanding of a key measurement principle that is undeveloped in many other children. For example, Grant and Kline (2003) describe a Grade One class where a difference in the unit of measurement (children's feet lengths) led to a dispute over the actual measure of a distance. Grant and Kline found that 'a significant number of students thought that smaller feet would lead to a smaller measure' (p. 52). This is an interesting contrast to the child in this project, who realised that the teacher's thick fingers would lead to a smaller number of 'counts'.

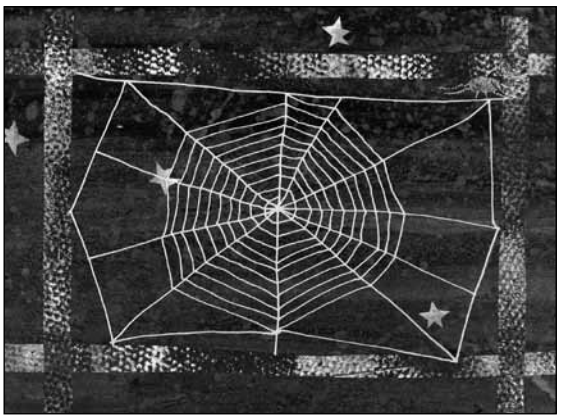
These measuring activities require repeating a natural measuring unit. While doing so, the children meet the requirement of fairness—that is to say, it is necessary to have a consistent unit, the awareness of which can help them develop an early understanding of the relationship between the unit of measurement and the measurement result, as we have seen. One might think this is a bit much for one reading session but, as we have shown, all these learning experiences are possible with a picture book like the one about the princess with the long hair.

Discussion

In this article we have illustrated how the reading of picture books can stimulate mathematical thinking about geometry, data representation and measurement. We have seen, as most experts believe, that young children possess a substantial amount of informal knowledge about mathematics. As we have shown, picture books can offer a meaningful context for learning mathematics, and provide an informal basis of experience with mathematical ideas that can be a springboard for more formal levels of understanding. Piaget's claim that conceptual knowledge stems from the inventive activities of the child, through actions on objects (including mental objects), rather than from transmission derived from teachers or others, clearly supports the use of picture books for developing conceptual knowledge (Piaget, 1974). Lambert and Clyde (2000) argue that the 'key developmental needs during these [kindergarten] years' (p. 134) are exploring, creating and communicating, each of which flow naturally from picture book experiences as described in this article.

Apart from the different 'cognitive hooks' (Lovitt & Clarke, 1992) that children get from the books individually, another attribute of picture books is the fact that they may reinforce one another. For example, the experiences with measuring the hair of the princess is again brought to life when discussing the length of the thread of a spider's web in the book *De spin die het te druk had [The very busy spider]* (Carle, 1985) (see Figure 7).

Figure 7. Page 22 of the book *De spin die het te druk.* [*The very busy spider*] (Carle, 1985)



In the same way, the book about the princess with the long hair and the book about the surprise also have something in common that can strengthen the children's understanding of transformations from linear to planar structures and vice versa. At the end of the book about the princess with the long hair, the hair is draped in such a way that the linear hair becomes a plane in the form of a blanket under which the princess and the strongman are snuggling in order to protect themselves from the cold. In the book about the surprise, the sheep uses its (planar) fleece to spin (linear) thread that, later on, is used to knit a jumper for the giraffe; thus the linear thread has again formed a planar structure.

Picture books also have the power to engage and focus the attention of a group of children. This can facilitate interactions between the children, as we have described earlier in the case of the book about the doll in the toilet, where B, I and K support each other. Clearly, the peer group interaction, stimulated by the picture book, can play a vital role in children's conceptual and language development.

Another reason that picture books are powerful tools for providing young children with a learning environment where they can explore and build up preliminary notions of mathematics-related concepts has to do with what happens when the teacher has closed the picture book. The children's dearest wish is for the teacher to read the book again, so that they again can measure the

hair with their fingertips, and compare their results with those of the teacher. All learning needs rehearsal, and often it is not easy to organise and keep children engaged. In the case of picture books, it is different. It is a case of 'Please, can we do it once again ...'

Recommendations

The examples described in this article show how easily picture books aid a teacher in developing and maintaining an educative discussion using a well-chosen book. When selecting picture books for stimulating mathematical thinking, the characteristics the books should have are at least the following: a good story, engaging for the children, and with mathematics readily available but not too blatant. Further, picture books that open children's eyes to a wide range of mathematical topics are preferable to simply using only counting books.

It must be remembered, too, that picture books can be read, enjoyed and continue to develop mathematical thinking in subsequent readings. While some children will grasp ideas at the first reading, others will need repeated exposure to the ideas found in the picture books. In addition, all children as they develop will find new or deeper mathematical meanings in a story. It is clear from the examples shown here that children build on one another's ideas to extend their own thinking, and rereading will also provide further opportunities for this type of peer learning.

Doing mathematics stimulated by picture books is not merely a kindergarten activity, but can extend into primary school grade classes—since, according to Ginsberg (1996), the primary teacher's role is to make links between children's informal mathematics and the more formal mathematics found in primary school. We argue that this is made easier through early contact with, and thinking about, mathematical ideas, particularly when they are presented in picture books which are read in group settings.

This is clearly shown in the picture books included in this article. For example, in the story of the princess with long hair, the children were able to measure the hair with fingers, and relate this to real-world measurements (metres). In addition, they could see that the size of the finger made a difference to the measurement value, a significant step in learning about measuring. In the book about the doll in the toilet, the children came across a new way of representing objects from the physical world and got the opportunity—maybe for the first time—to have a look inside this three-dimensional world by means of cross-sections displayed two-dimensionally. The picture book about the surprise also brought the children into some new mathematical territory, measuring growth and depicting it in a graph. Most astonishing for us was the ease with which the children understood what the sheep did with the ruler and the scale, and what the two lines meant on the graph.

The authors and illustrators of these picture books, which are of high literary quality, just wanted to tell an intriguing story—but at the same time they did something more. By having the long hair laid down in a spiral form and in a sinuate shape; by making the doll visible through creating cross-sections; and by providing the sheep with a ruler, a scale and an 'adult' graph that shows measuring results, the creators of these books—probably without any intention of teaching children mathematics—built opportunities that gave children access to mathematics. We would like to recommend that teachers of young children take advantage of what picture books can offer.

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