Does the Present Mathematics Curriculum Effectively Promote the Acquisition of Clock Reading? A Comparative Study of Chinese and Flemish Children's Clock reading Abilities.

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Abstract

The present study reexamines the adoption of clock reading skills in the primary mathematics curriculum. In many Western countries, the mathematics curriculum adopts a number of age-related stages for teaching clock reading skills, that were defined by early research (e.g., Friedman & laycock, 1989; Piaget, 1969). Through a comparison of Flemish and Chinese student's clock reading abilities, the current study examines whether these age-related stages are a solid base for teaching clock reading skills. By means of both quantitative (ANOVA's) and qualitative (textbook analysis) methods, the present study indicates that the alternative way of teaching clock reading skills in China, i.e., at the age of six instead of staggered out over several grades, results in a two years earlier acquisition of clock reading skills. This indicates that the previously age-related stages in children's acquisition of clock reading are not universal, nor the most effective way to teach these skills to young children.

Does the Present Mathematics Curriculum Effectively Promote the Acquisition of Clock Reading? A Comparative Study of Chinese and Flemish Children's Clock reading Abilities.

Primary school teachers report that time measurement is a difficult subject in mathematics education in nearly every grade of primary school (Van Steenbrugge, Valcke, & Desoete, 2010). Being confronted with children's difficulties in learning to tell the time and at the same time not fully understanding why this task is such a difficult one or how it should be taught, primary school teachers are obviously in need of clear evidence-based strategies for teaching this subject. However, due to a lack of research upon the pedagogy of time, the current adoption of instructional programs and practices for teaching time-related competences such as clock reading, is rather driven by ideology, faddism, politics and marketing than by empirical evidence (Burny, Valcke, & Desoete, 2009; Slavin, 2008).

Since research of the pedagogy of time is scarce, Western clock reading instruction builds on dated research that defined age-related stages in children's development of clock reading skills. These early studies, conducted between the 1970ies and the 1990ies, concluded that children master hour times at the age of six, half hour times at the age of seven, 5-min times at the age of eight or nine and 1-min times at the age of ten (Boulton-Lewis, Wilss, & Mutch, 1997; Case, 1992; Case, Sandieson, & Dennis, 1986; Friedman & Laycock, 1989; Griffin, Case, & Sandieson, 1992; Siegler & McGilly, 1989). However, it should be noted that, aiming at a theoretical insight in children's natural cognitive development, these studies did not account for the role of instructional processes. In fact, the basic assumption of this early research was that cognitive development can never be the outcome of learning that is invoked by instructional processes (Brainerd, 1978) and children's assimilation of time conceptions is basically subject to maturation (Levin & Gilat, 1983; Piaget, 1969; Siegler & Richards, 1979).

However, in contrast to previous research, recent studies question the premise that the development of time conceptions is subject to maturation and stresses the role of education, concluding that children's ability in the area of time really depends upon instruction (Dawson, 2004; Hodkinson, 2004; Monroe, Orme, & Erickson, 2002). Hodkinson (2004), for example, pointed out that we have continuously underestimated what young children can learn with regard to the concept of historical time and concluded that the English curriculum does not offer an effective approach to the development of temporal cognition. With regard to clock reading, however, the role of learning and instruction has not been examined in depth. Nevertheless, as the ability to read the clock is a fundamental life skill that allows us to plan our daily activities, to get organized and to function in a society that is driven by time (Bock, Irwin, Davidson, & Levelt, 2003; Friedman & Laycock, 1989), it is worthwhile to reexamine the integration of clock reading skills in the mathematics curriculum.

As several studies show that China and other East Asian countries (e.g., Japan, South Korea, Taiwan) have consistently outperformed the United States and many other industrialized nations in mathematics achievement (e.g.,Stevenson, Chen, & Lee, 1993; Stevenson, Lee, & Stigler, 1986; Z. Zhou, Peverly, & Lin, 2004; Z. Zhou, Peverly, S.T., Boehm, A.E., & Chongde, L., 2000), it seems interesting to examine whether Chinese children also outperform Western children in clock reading. Yet, a recent study of Burny, Valcke and Desoete (2010) indicated that children's accuracy in clock reading is related to their mathematical competence and a closer look at the Chinese mathematics curriculum shows substantial differences with the typically Western curriculum that adopts the age-related stages as defined in early research of clock reading in children (e.g.,Friedman & Laycock, 1989; Piaget, 1969; Siegler & McGilly, 1989).

Thus, in order to find out whether the previously defined age-related stages in children's acquisition of clock reading skills are a solid base for teaching clock reading skills,

the present study compares the outcomes of two distinct curricula: (1) the Flemish curriculum for clock reading, which is a typically Western curriculum that integrates the previously defined age-related stages, and (2) the Chinese curriculum, that adopts a different structure and suggests to teach clock reading skills at a younger age. As previous studies show that mathematics curriculum standards and the curriculum materials that are used in the classroom, highly influence what is taught and learned (Reys, Reys, Lapan, Holliday, & Wasman, 2003), it is argued that Chinese children are likely to obtain clock reading skills at a younger age than Flemish children. If so, this would indicate that the acquisition of clock reading skills is not solely a matter of maturation and that the current Western approach to teaching clock reading skills might not be the most accurate way of teaching these skills.

Aim of the present study

At a theoretical level, the current study addresses the question whether the acquisition of clock reading skills is subject to maturation or rather driven by instructional processes. In other words, it reexamines the previously defined age-related stages in children's acquisition of clock reading skills.

At a practical level, the present study aims to reexamine the current Flemish curriculum for clock reading and to define whether clock reading instruction can be speeded up. By means of a qualitative comparison of the Chinese and the Dutch mathematics curriculum standards and textbooks, the current study compares two distinct teaching practices for clock reading and considers what can be learned from an alternative practice.

Methods

Respondents

For this study, a total of 11108 children was tested on clock reading. The results of 149 Flemish children (Flanders is the Dutch speaking part of Belgium) are compared to the results of 10595 Chinese children from the region of Beijing. The sample of Flemish children contains 149 first graders (70 boys, 79 girls), 151 second graders (81 boys, 70 girls), 137 third graders (76 boys, 61 girls), 144 fourth graders (67 boys, 77 girls, 119 fifth graders (58 boys, 61 girls) and 84 sixth graders (48 boys, 36 girls). All children in the Flemish sample attend a Flemish primary school and are taught in Dutch. The sample of Chinese children involves 1857 first graders (954 boys, 903 girls), 1855 second graders (972 boys, 883 girls), 1805 third graders (933 boys, 872 girls), 1831 fourth graders (979 boys, 852 girls), 1751 fifth graders (904 boys, 847 girls) and 1860 sixth graders (943 boys, 917 girls). All children in the Chinese sample receive instruction in Chinese. Table 1 provides an overview of descriptive information about the sample of Flemish and Chinese students.

< Insert Table 1 about here >

Materials

All children in the sample completed a number of clock reading tasks. For the Chinese children, these tasks were part of a larger mathematics test. The Flemish children completed a specific clock reading test. The tests have overlapping items in order to make comparison of both samples possible. Chinese first graders completed five clock reading tasks: they were asked to read three analog clocks (10:00, 08:30 and 14:40) and to draw the hands corresponding to two digitally presented clock times (10:30 and 05:00). Flemish first graders completed four of these items (reading: 10:00, 08:30, and writing: 14:30 and 05:00) and additionally, they were asked to read 10:15 and to draw the hands for 03:15. In second grade,

Chinese children completed four clock reading items: three items on reading analog clock times (14:40, 11:42, 08:24) and one on drawing the clock hands for 10:30. Flemish second graders completed eight clock reading items: four on reading analog clock times (10:00, 8:00, 10:15, 14:40) and four on drawing hands on an analog clock (5:00, 10:30, 3:15, 6:10). Chinese children in grade three, four, five and six were asked to read three clock times on an analog clock (14:40, 11:42, 8:24). Flemish children in grade three were asked to read four analog clocks (8:30, 10:15, 14:40, 11:42) and to draw the hands for four other clock times (3:15, 3:36, 4:02, 6:10). Flemish students in grades four, five and six were presented four analog clock times (10:15, 14:40, 11:42, 1:02) and were asked to draw the clock hands for 3:36, 4:02, 5:27 and 6:10.

For the textbook analysis, a commonly used Chinese mathematics textbook series (SHUXUE) was compared to a frequently used textbook series in Flanders (KOMPAS). Both textbook series are geared to the mathematics standards and the mathematics curriculum that currently determine mathematics instruction in Flemish and Chinese primary education. The Chinese method "Shuxue" consists of two student textbooks per grade: one for each semester. Each textbook includes ten units that each address a specific topic in mathematics. Teaching one unit takes 8 lessons of forty minutes. Each student textbook contains about 120 A5 pages of exercises and is well illustrated to become more attractive to children. The Flemish method "Kompas" includes several textbooks per grade: four student textbooks in grades one and two and three student textbooks in grades three to six, making a total of 240 A4 pages of exercises in each grade. The textbooks consist of short units that can be taught in one mathematics lesson (50 minutes). In each week, one lesson is dedicated to each of the five domains in mathematics: measurement, geometry, number knowledge, calculation and problem solving. Comparable to the Chinese textbooks, the Flemish student textbooks are well illustrated and attractive for primary school children. In Table 2, some background

information on the organization of mathematics instruction in both textbook series is presented.

< Insert Table 2 about here >

Procedure

The current study consists of two major parts: 1) quantitative analyses of students' performance in clock reading and 2) a qualitative analysis of mathematics textbooks . With regard to the quantitative part of the study, clock reading skills of Chinese and Flemish children were tested with paper-and-pencil tests. Children were tested in their classroom during the months December, January and February 2009, under supervision of a trained researcher. The results of these tests were analyzed with the statistical software package SPSS 18.0. Students' clock reading abilities in both countries were compared by means of ANOVA's. Because of the large number of comparisons (n=21), a correction factor (Bonferroni) was added to the analyses.

Regarding the qualitative textbook analysis, the authors built on the work of Pingel (2009), who described methods for textbook analysis. The analysis of two mathematics textbook series was conducted in two phases. First, the contents of both textbooks were interpreted against the mathematics curriculum in both countries. Second, a content analysis was conducted to find out what the text tells us, whether it is in accordance with academic research and whether it sufficiently covers the topic of clock reading.

Results

The results of this study are presented in three parts. A first part of the result section reports on quantitative analyses on Chinese and Flemish children's accuracy in clock reading. A second part addresses structural differences in how the subject of clock reading is integrated

in the Flemish and Chinese mathematics curriculum standards and textbooks and in a third part, the results of a content analysis on two frequently used textbook series “Shuxue “ and “Kompas” are presented.

Clock reading accuracy of Flemish and Chinese students

Table 3 presents the mean proportion of correct answers on each subtasks for both Chinese and Flemish children in each grade of primary education. The differences in clock reading performance between Chinese and Flemish children were examined by ANOVA’s. Because of the large number of comparisons (n=21), a correction factor (Bonferroni) was added to the analyses. Differences are now considered significant when p<.002 (α=.05, k=21).

< Insert Table 3 about here >

In grade 1, we could only compare for hour and half hour clock times. Both Flemish and Chinese children had been taught these tasks at the moment of testing. With regard to the reading of hour times (10:00) on an analog clock, Flemish children perform significantly better than their Chinese peers, F(1,2005)=112.88, p<.002. Considering the reading of half hour times (8:30), Chinese children perform significantly better than Flemish children, F(1,2005)=109.32, p<.002. In second grade, five minute clock times are added to the analysis, showing that Chinese children perform significantly better than their Flemish peers, F(1,1190)=238,12, p<.002, who hadn’t been taught this task at the moment of testing. This advantage of Chinese children over Flemish peers in reading five minute clock times remains in grade three, F(1,1938)=98.14, p<.002, grade four, F(1,1970)=9.28, p<.002 and grade five, F(1,1869)=13.92, p<.002. It is only in grade six that Flemish children perform equally well on reading five minute clock times on an analog clock, F(1,1943)=.24, p=ns. With regard to the reading of one minute clock times on an analog clock, Chinese children perform better than

Flemish children in grade three, $F(1,1939)=70.60$, $p<.002$, grade four, $F(1,1966)=11.28$, $p<.002$, grade five, $F(1,1869)=28.93$, $p<.002$, and grade six, $F(1,1943)=11.24$, $p<.002$.

In grades one and two, children were not only asked to read analog clocks, they also had to draw the hands of the clock. In grade one, we notice no significant differences between Chinese (M=.59, SD=.49) and Flemish children (M=.61, SD=.49) in drawing the hands for an hour time (05:00), $F(1,2003)=.074$, p=ns. In drawing the hands for a half hour time (10:30), however, Chinese children (M=.41, SD=.49) performed significantly better than Flemish children (M=.21, SD=.41), $F(1,2002)=23.67$, $p<.002$. In second grade, when Flemish children are taught to read and write half hour clock times, the inverse is noticed: Flemish children (M=.84, SD=.37) perform significantly better in drawing the hands for 10:30 than Chinese children (M=.34, SD=.48), $F(1,2003)=156.91$, $p<.002$.

Considering the acquisition of complex clock reading skills, i.e., reading five minute and one minute clock times on an analog clock, ANOVA's show that Chinese children are two years ahead of Flemish children: there is no significant difference in the accuracy of Chinese first graders and Flemish third graders in reading 14:40, $F(1, 1990)=.101$, p=ns, Chinese second graders are as accurate as Flemish fourth graders in reading 14:40, $F(1,1994)=.079$, p=ns, and in reading 11:42, $F(1,1990)=.662$, p=ns, and Chinese third graders are performing only slightly more accurate than Flemish fifth graders in reading 14:40, $F(1, 1923)=6.17$, $p=.013$, and in reading 11.42, $F(1, 1923)=6.02$, $p=.014$. Furthermore, there is no difference in accuracy between Chinese fourth graders and Flemish sixth graders in reading 14:40, $F(1, 1914)=.327$, p=ns; and reading 11:42, $F(1, 1914)=1.41$, p=ns.

Clock reading in the Flemish and Chinese mathematics curriculum standards and textbooks

In order to find an explanation for these differences in clock reading accuracy between Chinese and Flemish children, a qualitative analysis of mathematics curriculum standards and textbooks is conducted. Mathematics curriculum standards can be defined as the set of learning goals articulated across grades that outline the intended mathematics content and the process goals at particular points in time (Reys, et al., 2003). In both Belgium and China, the government determined final attainment goals for primary education. With regard to time measurement, the Flemish government determined that primary school children should reach four goals: (1) they have to know commonly used quantities and units of measure with regard to the concept of time, (2) they must be familiar with the symbols, notation systems and conventions with regard to measuring time, (3) they have to be able to read analog and digital clocks and (4) they have to be able to measure time intervals and know the relation between seconds, minutes and hours. These final attainment goals have to be reached by the end of grade six. The Chinese mathematics curriculum standards include three goals with regard to the concept of time, that have to be reached by the end of grade three: (1) children have to be able to deal with time in concrete situations, (2) they have to be able to recognize clock times on a watch and (3) they have to be able to recognize and to measure the length of time intervals in relation to their own life experiences. These final attainment goals are then integrated into a more specific mathematics curriculum and translated into curriculum materials, that provide guidance and structure to teachers as they enact the intended school mathematics curriculum (Reys, et al., 2003).

With regard to clock reading, the structure of the mathematics curriculum strongly differs in both countries. In Flemish primary schools, similar to U.S. schools, a spiral curriculum is adopted in mathematics education: topics are briefly introduced and then reviewed in successive years to build on previous learning (Askey, 1999; Jiang, 1995; Moy & Peverly, 2005). For clock reading, this is translated into a stepwise curriculum over several

grades. In first grade, children are introduced to reading hour and half hour clock times on an analog clock. In this grade, children are also introduced to measuring simple time intervals and solving word problems containing hour and half hour clock times. In grade two, hour and half hour clock times are repeated and later on, quarter past times are introduced. Again, integrated tasks are presented along with the basic clock reading tasks. In grade three, Flemish children are taught to read and write five minute and one minute clock tasks on analog clocks and have to acquire digital clock reading up until one minute precise. Reading the time up until one second precise is taught in grade four. In grade five and six, basic clock reading skills are repeated once in a while and integrated skills pop up in lessons on problem solving.

In Chinese primary education, the general tendency to teach mathematics subjects sequentially and non-repetitively (Askey, 1999; Jiang, 1995; Moy & Peverly, 2005) is also dominating clock reading instruction: In grade one, students are taught to read hour and half hour times on analog and digital clocks in the first half of the school year (textbook 1) and five minute and one minute clock times in the second half (textbook 2). In second grade, no clock reading lessons are included in the mathematics textbook. In grade three, one chapter is dedicated to clock reading instruction, containing integrated clock reading tasks such as measuring time intervals, solving word problems and linking clock times to daily activities. With regard to basic clock reading skills, Chinese students are introduced to reading analog and digital clocks up until one second precise. From grade four on, no specific clock reading instruction is included in the mathematics textbooks. As such, the goal of recognizing clock times is addressed in grade one and the goals of dealing with time in daily life and measuring time intervals is addressed in grade three. The Chinese curriculum does not incorporate any forms of revision apart from the specific units on clock reading, which is in line with the sequential and non-repetitive nature of the Chinese mathematics curriculum.

Content analysis

Next to an analysis of the structure of the mathematics curriculum and the sequence for teaching clock reading skills, the contents that are taught with regard to clock reading are analyzed. In this section we will focus on the number of lessons, the time spent on clock reading instruction, the number of exercises that is presented in textbooks and the type of exercises children are confronted with.

Number of clock reading lessons. An in-depth analysis of the Chinese textbook series "Shuxue" reveals that Chinese pupils spend about twelve hours learning to read analog and digital clock times in first grade. A first chapter in the textbook , which represents about six hours of teaching, is presented in the first semester of first grade and addresses hour and half hour clock times. A second chapter, in the second semester of first grade addresses five minute and one minute clock times and again represents six hours of teaching. An additional six hours of instruction in grade three addresses integrated clock reading skills, such as problem solving and measuring time intervals. Following the Chinese textbooks, children should thus be able to read analog and digital clock times and operate on them after 18 hours of instruction and practice. The time spent on clock reading instruction is about 2.5% of the total time that is spent on teaching mathematics in primary education.

< Insert Table 4 about here >

A closer look at the Flemish textbook series "Kompas" reveals a more complex time schedule with lots of repetition.In grades one and two, the mathematics textbook contains 9 lessons of 25 minutes on clock reading, which is good for three hours and forty-five minutes in each grade. In grade three, 4 lessons of fifty minutes (= 3h20min) are spent on the teaching of five minute and one minute clock times and in grade four, two hours and thirty minutes (=3 lessons of 50 minutes) are dedicated to the teaching of clock reading skills. In fifth grade, 2 lessons and some review exercises on time, speed and distance problems are good for two

hours of teaching. In grade six, no specific lessons on time are included in the textbook but revision exercises are integrated in other lessons on for example problem solving. This makes a total of 27 lessons on clock reading during primary education, which makes a total of 15 hours and 20 minutes. In Flanders, clock reading instruction takes 2% of the teaching time for mathematics. An overview of the number of clock reading lessons in each grade is provided in Table 4.

Number of exercises on clock reading subtasks. Both the Flemish and the Chinese mathematics textbook include exercises on basic clock reading skills and integrated clock reading skills. Basic clock reading skills are considered these exercises that focus on technical clock reading. In this category, we distinguish analog and digital clock reading tasks. Integrated clock reading skills on the other hand, refer to tasks that demand an integration of technical clock reading skills with other mathematical competences. For example, measuring time intervals and solving time-related word problems. Table 5 shows the number of exercises on each subtask in both the Flemish and the Chinese textbooks for grades one to six.

< Insert Table 5 about here >

The Flemish textbook series 'Kompas', includes 553 exercises on clock reading. These exercises are divided over six grades of primary education. First grade textbooks, contain 116 exercises that address the reading of hour and half hour clock times on an analog clock (n=79) and the subsequent integrated skills (n=37). In the second grade textbooks, 155 exercises are included, of which 102 are dedicated to reading and writing hour, half hour and quarter past times on an analog clock, and 53 exercises focus on integrated skills. In grade three, 145 exercises are presented to Flemish children: 68 exercises on analog clock reading, 33 exercises on digital clock reading and 44 exercises on integrated skills. Textbooks for fourth graders include 64 exercises (21 on analog clock reading, 6 on digital clock reading

and 37 on integrated skills; in grade five, 56 exercises are presented (10 on analog clock reading, 2 on digital clock reading and 44 on integrated skills); and in grade six, the textbook includes 18 exercises (4 on analog clock reading and 14 on integrated skills).

The Chinese textbook series ‘shuxue’, on the other hand, only contains 148 exercises on clock reading, that are offered in grade one (*n*=91) and grade three (*n*=57). In first grade, the focus lies on basic analog clock reading (*n*=56) and basic digital clock reading (*n*=30). Five exercises address integrated clock reading skills. In third grade, technical analog clock reading (*n*=8) and digital clock reading (*n*=6) exercises become scarce in favor of exercises on integrated skills (*n*=43).

The larger number of exercises in the Flemish textbooks reflects an overall difference between the Chinese and Flemish textbooks: Flemish textbooks are in general more extensive and include more repetitive exercises. Yet, the Chinese textbooks provide a more balanced program, with 43.24% of all clock reading exercises focusing on basic analog clock reading, 24.33 % on basic digital clock reading and 32.43% of exercises focusing on integrated skills. The Flemish textbook shows a great emphasis on analog clock reading (51.17%) and integrated skills (41.42%), but disregards digital clock reading skills (7.41% of all exercises). Moreover, the Chinese textbooks provide analog and digital clocks simultaneously from first grade on, whereas the Flemish textbook only introduces digital clocks in third grade. Another difference between both textbooks can be found in the combination of basic and integrated skills. Whereas the Flemish textbook combines basic skills with appropriate integrated skills in each grade, the Chinese textbook offers basis skills in grade one and integrated skills in grade three.

Types of exercises on clock reading. Although both textbooks include exercises on the same contents, i.e. analog and digital clock reading, measuring time intervals, solving

time-related problems and using timetables, there are slight variations in how these contents are presented. As this study is limited to children's ability to read the clock, we will focus on exercises that address basic clock reading skills, rather than integrated clock reading skills.

In the Chinese textbook series, "shuxue", two types of exercises are offered to teach basic analog and digital clock reading. In a first type of exercises, children are asked to write down the clock time as they would pronounce it in daily communication, for example "it is ten past four". A second type of exercises involves the transposing of analog clock times into a digital format and vice versa. A variation on this type of exercise involves the linking of two corresponding analog and digital clock times. Whereas Chinese children are taught to read analog and digital clock times only through these two types of exercises, the Flemish textbook also includes other tasks, such as drawing the hands of an analog clock and transposing a relative time expression to a digital clock display. These tasks are common in the Flemish textbook but do not appear in the Chinese textbook.

Both the Flemish and the Chinese textbooks link exercises on clock reading to daily activities to give meaning to the tasks. In Chinese textbooks, a significant number of exercises links clock times to daily activities in an implicit way: by adding pictures of activities to clock reading tasks, the children are pointed at the meaning of these clock times. More active tasks in this area involve linking digital clock times to the corresponding picture of an activity or estimating the duration of a daily activity (e.g. brushing teeth). As in the Chinese textbooks, Flemish textbooks also provide pictures or short sentences that refer to an activity linked to a specific clock time. A rather small amount of exercises explicitly addresses the link between clock times and daily activities by asking the children to mark the correct activity with a clock time or to link a clock time to a picture of an activity.

With regard to integrated clock reading skills, such as interval measurement, problem solving and using timetables it can be stated that there are only small differences between the Chinese and the Flemish textbook series. In general, very similar exercises are provided. As the Flemish textbook series includes a larger number of exercises, Flemish children are offered more variety in exercises. However, these alternative formats seem to offer little added value.

Discussion

The main purpose of this study was to determine whether children's acquisition of clock reading skills is subject to maturation or is rather driven by instruction. Previous studies have continuously built upon the premise that learning to read the clock is mainly a matter of maturation (Levin & Gilat, 1983; Piaget, 1969; Siegler & Richards, 1979). In light of this assumption, early studies suggested a number of age-related stages in children's development of clock reading skills, stating that children can read hour times at the age of six, half hour times at the age of seven, five minute clock times at the age of eight or nine and one minute times at the age of ten (Boulton-Lewis, et al., 1997; Case, 1992; Case, et al., 1986; Friedman & Laycock, 1989). These age-related stages have been adopted in the educational practice for clock reading in many western countries, such as Belgium.

However, as recent studies indicate a strong impact of instruction on children's development of time conceptions (Dawson, 2004; Hodkinson, 2004; Monroe, et al., 2002), it can be questioned whether the adoption of these specific age-related stages in the curriculum for clock reading is the most effective way to teach clock reading skills. By comparing the accuracy in clock reading of Flemish primary school children with the skills of Chinese children, the impact of the mathematics curriculum and textbooks on children's clock reading skills is studied.

The results of the present study show that Flemish children indeed acquire clock reading skills according to the previously described age-related stages: hour times are mastered at the age of six, half hour times at the age of seven, five minute times at the age of nine and one minute clock times become accurate from the age of eleven, which is even later than suggested by previous studies (e.g., Boulton-Lewis, et al., 1997; Case, 1992; Case, et al., 1986; Friedman & Laycock, 1989). Chinese children, on the other hand, acquire complex clock reading skills, i.e. reading five minute and one minute clock times, at a younger age: the current research results show that Chinese pupils can accurately read five minute clock times at the age of seven and one minute clock times at the age of eight, which is two years earlier than Flemish children.

This difference in accuracy and development of clock reading skills between Chinese and Flemish children can be explained by the sequence for teaching clock reading skills in the mathematics curriculum: Chinese children are taught to read five minute and one minute clock times on analog and digital clocks in first grade of primary education (age 7), whereas Flemish children are only taught to read five minute and one minute clock times in grade three or four (age 9-10). Given the fact that Chinese children are evenly accurate as Flemish children in reading these clock times after the initial instruction in first grade, the current results provide evidence for the hypothesis tht clock reading skills are driven by learning and instructional processes, rather than by maturation. Additionally, the current results show that, although the accuracy of both Chinese and Flemish students still improves in successive years after the initial instruction, the two year margin between Chinese and Flemish students persists. It should thus be concluded that there are no solid reasons to postpone clock reading instruction until children are mature enough to learn this task.

The most obvious explanation for these differences in clock reading accuracy between Chinese and Flemish children is to be found in the mathematics curriculum: Chinese children

are taught complex clock reading skills two years earlier than Flemish children and therefore they obtain accuracy in these tasks two years earlier. However, students learning is not only influenced by when a subject is taught but also by how it is taught (Reys, et al., 2003). Yet, a qualitative comparison of student textbooks indicated that there are no significant differences between Chinese and Flemish textbooks in the number of lessons that are spent to clock reading instruction, nor are there significant differences in the time spent on this subject in mathematics classes. With regard to the number of exercises, it should be noted that Chinese textbooks include only a quarter of the number of exercises in Flemish textbooks. However, this does not guarantee that Chinese teachers offer less practice to their students in and/or outside the classroom, as Chinese students study through homework practice much more than Flemish children. Considering the type of exercises, little differences are noticed between both textbook series. Based on the results of the qualitative textbook analysis, it can be concluded that the instructional practices with regard to clock reading do not significantly differ in both countries. This high level of similarity in contents between the Chinese and the Flemish textbooks is in line with the finding that Chinese children do not perform qualitatively different than their Flemish peers, they are just two years ahead.

An interesting finding of this study concerns the improvement in clock reading accuracy after the initial classroom instruction in both Flemish and Chinese children. In Flemish education, this improvement is consistent with the spiral nature of the mathematics curriculum, that involves lots of repetition to build on previous learning (Askey, 1999; Moy & Peverly, 2005). The analysis of the Flemish textbooks indeed shows that clock reading skills are repeated in successive years. The Chinese curriculum, however, is characterized by its non-repetitive nature (Askey, 1999; Moy & Peverly, 2005) and therefore does not suggest that children would gain accuracy after instruction. Yet, the current analyses do not provide information on the actual classroom practice nor can we pronounce upon the children's daily

experiences with clocks. Therefore, further research should apply observational strategies in to study the actual teacher behavior and homework practice in order to define differences between both countries in the actual teaching and homework practice.

Based on the current research results, it can be stated that the sequence for teaching clock reading skills that is adopted in most Western mathematics curricula is not the most effective one. Given the results of the Chinese children in this study, it is obvious that children are able to learn to read the clock at a younger age. However, two important differences between Chinese and Flemish children should be taken into account before we randomly adopt the Chinese curriculum for clock reading in Western classrooms. First, many studies have showed Chinese children to outperform Western children in mathematics (e.g.,Stevenson, Chen, & Lee, 1993; Stevenson, Lee, & Stigler, 1986; Z. Zhou, Peverly, & Lin, 2004; Z. Zhou, Peverly, S.T., Boehm, A.E., & Chongde, L., 2000). As a recent study of Burny, Valcke and Desoete (2010) indicated that children strongly rely on their mathematical knowledge in obtaining clock reading skills, it should not be disregarded that stronger mathematical knowledge in young Chinese children could influence their ability to learn clock reading skills. Second, there is an important linguistic difference between Chinese time telling and Dutch time telling.

Time telling in Chinese is straightforward and very similar to the digital clock format. For example, 05:23 is read as "*five hours twenty-three minutes*". In Dutch, on the other hand, time telling is more complex. A preference for relative time expressions in combination with changing reference points, results in complicated time expressions (e.g. 05:23 is read as "*7 before half 6*"). Summarizing, time telling in Dutch consists of three types of expressions: times to the upcoming hour (e.g. *ten to three*), times past the present hour (e.g. *seven past two*) and times referring to the half hour (e.g. *seven to half 6*). As a result of this complicated

linguistic format, many Flemish children struggle the language for telling time, which makes time telling even more challenging for Flemish children.

Next to these differences, further research should account for cultural differences between Chinese students and Western children. Yet, the results of this study are interesting as they question a strong premise in current teaching practices. Although many primary school teachers are convinced of the fact that clock reading is a very difficult subject for young children (Van Steenbrugge, et al., 2010), the present results show that is not impossible for children to obtain a complex skill such as telling time at a young age. As such, this study confirms the statement of Hodkinson (2004) that we underestimate what young children can learn with regard to the concept of time.

Conclusion

The present research results suggest that children's acquisition of clock reading skills is rather driven by learning and instruction, than it is subject to maturation. This finding falters the premise that children acquire clock reading skills according to fixed age-related stages (e.g. Friedman & Laycock, 1989; Piaget, 1969). Although these age-related stages have determined Western educational practice with regard to the teaching of clock reading skills for several decades, the current results show that this might not be the most effective sequence to teach these skills to young children. Given the outcomes of this study it can be argued that the sequence for teaching clock reading skills as it is adopted in the mathematics curriculum should not be taken for granted and could be reconsidered in order to promote clock reading abilities in young children.

With regard to the teaching of clock reading skills, the current research results revealed that there are no obvious differences between China and Belgium in how clock reading skills are included in the mathematics textbooks. Although this increases

comparability between both groups, it also implies that, merely based on the Chinese mathematics textbooks, little recommendations can be made towards Western teaching practice. Further research focusing on the actual classroom practice of Chinese and Flemish teachers is needed in order to determine whether there are differences in how clock reading is taught in both countries. Yet, the current research results question an established educational practice and reveals that young children are capable of learning complex clock reading skills at a younger age than was generally believed over the past forty years.

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Tables

Table 1. Number of respondents and mean age for each condition

	Number of respondents (N)						Mean age (SD)	
	Belgium			China			Belgium	China
Grade	Total	Male	Female	Total	Male	Female		
1	149	70	79	1857	954	903	6.38 (.54)	6.28 (.50)
2	151	81	70	1855	972	883	7.46 (.63)	7.56 (.65)
3	137	76	61	1805	933	872	8.72 (.79)	8.53 (.72)
4	144	67	77	1831	979	852	9.41 (.62)	9.47 (.71)
5	119	58	61	1751	904	847	10.35 (.65)	10.62 (.74)
6	84	48	36	1860	943	917	11.44 (.67)	11.56 (.72)

Table 2. Comparison of main structural characteristics of the Chinese textbooks series SHUXUE and the Flemish textbook series KOMPAS.

	SHUXUE (China)	KOMPAS (Belgium)
Number of textbooks	2 per grade	3 or 4 per grade
Number of pages	240 A5 pages / grade	240 A4 pages / grade
Structure of textbooks	Divided in chapters: 10 chapters/textbook	Divided in weeks: 32 weeks/grade
Number of lessons	1 chapter = 9 lessons Total = 180 lessons/school year	1 week = 5 lessons Total = 160 lessons/school year
Duration of lessons	1 lesson = 40min	1 lesson = 50min
Total teaching time	120 hours	133 hours

Table 3. Mean proportion correct on the overlapping clock reading items for Flemish and Chinese students in each grade of primary education.

	Belgium				China			
age	10:00	8:30	14:40	11:42	10:00	8:30	14:40	11:42
6	.71*	.22	-	-	.59	.65*	.45	-
7	.96	.81	.06	-	-	-	.68*	.60
8	-	.87	.46	.34	-	-	.82*	.69*
9	-	-	.69	.57	-	-	.80*	.70*
10	-	-	.72	.58	-	-	.85*	.79*
11	-	-	.82	.64	-	-	.84	.80*

**significantly higher mean proportion correct answers than Flemish/Chinese children*

Table 4. Number of clock reading lessons and suggested teaching time in the Flemish and Chinese mathematics textbook.

Grade	**Teaching time**		**N lessons**	
	China	**Flanders**	**China**	**Flanders**
1	12h	3h45min	18 x 40min	9 x 25min
2	-	3h45min	-	9 x 25min
3	6h	3h20min	9 x 40min	4 x 50min
4	-	2h30min	-	3 x 50min
5	-	2h	-	2.5 x 50min
6	-	-	-	-
Total	18h	15h20min	27	27.5

Table 5. Number of exercises on each clock reading subtasks in the Flemish (F) and Chinese (C) mathematics textbook for each grade of primary education.

		Number of exercises															
		Grade 1		Grade2		Grade 3		Grade 4		Grade 5		Grade 6		**Total N**		**Total %**	
		F	C	F	C	F	C	F	C	F	C	F	C	**F**	**C**	**F**	**C**
BASIC SKILLS – analog clock reading	1. Hour	48	18	29		6								83	18	15.01	12.16
	2. Half hour	31	9	32		10								73	9	13.20	6.08
	3. Quarter past		4	41		19	1			1				60	5	10.85	3.38
	4. 5-min		14			10	5			2		3		15	19	2.71	12.84
	5. 1-min		11			23		5		4		1		33	11	5.97	7.43
	6. seconds		0				2	16		3				19	2	3.43	1.35
	subtotal	**79**	**56**	**102**	**0**	**68**	**8**	**21**	**0**	**10**	**0**	**4**		**283**	**64**	**51.17**	**43.24**
BASIC SKILLS – digital clock reading	7. Hour		13											-	13	.00	8.78
	8. Half hour		1			3				1				4	1	.72	.69
	9. Quarter past		2			6	1							6	3	1.08	2.03
	10. 5-min		12			7	5	1						8	17	1.45	11.48
	11. 1-min		2			17		5		1				23	2	4.16	1.35
	subtotal	**0**	**30**	**0**	**0**	**33**	**6**	**6**	**0**	**2**	**0**	**0**		**41**	**36**	**7.41**	**24.33**
INTEGRATED SKILLS	12. Measuring intervals	14	1	25		12	4	4		13				68	5	12.30	3.38
	13. Solving word problems	10	1	11		13	12	14		9		13		70	13	12.66	8.78
	14. Linking clock times to activities	13	2	12		1	12							26	14	4.70	9.46
	15. Link between time units and calculus		1	1		8	10	16		19				44	11	7.96	7.43
	16. Using timetables			4		10	5	3		3		1		21	5	3.80	3.38
	subtotal	**37**	**5**	**53**	**0**	**44**	**43**	**37**	**0**	**44**	**0**	**14**		**229**	**48**	**41.42**	**32.43**
	Total	**116**	**91**	**155**	**0**	**145**	**57**	**64**	**0**	**56**	**0**	**18**	**0**	**553**	**148**	**100**	**100**

F = Flanders, C= China, hour= reading hour times, half hour = reading half hour times, quarter past = reading quarter past or quarter to times, 5-min = reading the clock up until 5 minutes precise, 1-min= reading the clock up until 1 minute precis