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CAMBRIDGE Mathematics

ESPRESSO

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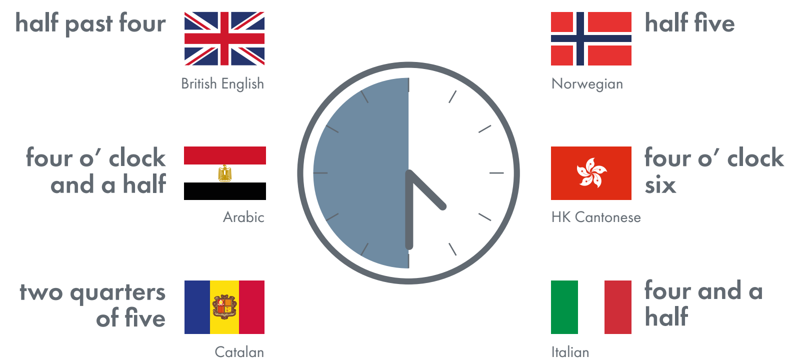
TALKING POINT:

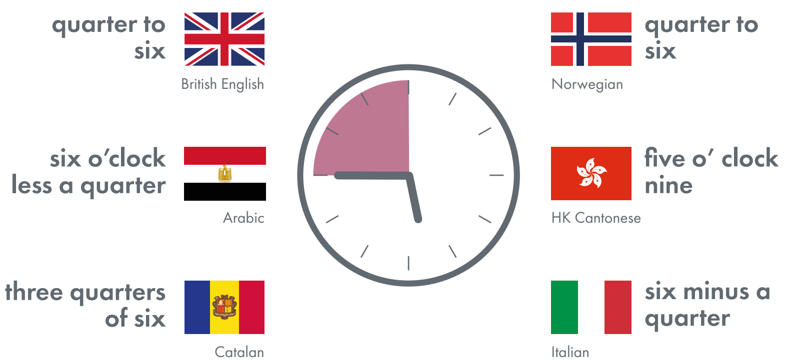
WHAT DOES RESEARCH SUGGEST ABOUT DEVELOPING CONCEPTS OF TIME?

IN SUMMARY

- Time is complex and foundational for learning within and outside mathematics, and also relies on language, spatial and memory skills; there is a lack of research around concepts of time
- Developing an understanding of time vocabulary, time intervals, elapsed time, and the sequencing of events is important alongside learning to tell the time
- Exploration of a diverse range of representations of time is recommended; in particular moving meaningfully between empty number line representations and circular scales, as on a clock face
- Explicitly instructing students in a systematic way of measuring, telling and calculating with time is supported by some evidence, although exploration and developing intuition by thinking about ideas of duration throughout the school day is also suggested as useful
- Concepts of time, especially elapsed time, are difficult and take many years to develop; it may be useful for children to learn to read digital time before using more complex analogue models
- Understanding and using time involves becoming fluent in visualising and composing and decomposing units, and language can present a barrier to working with clock time

Approximate translations of words used to tell the time in different languages





1

Time is of foundational importance in understanding the world. It is complex because it is an abstract concept that can be measured but not seen. Time is vital for all learning, because sorting, sequencing and ordering are the basis of systematically organising knowledge.[1] Children need to learn not only to tell the time but to build conceptual understanding of time vocabulary, time intervals, elapsed time, and sequencing of events.[2] Understanding and using concepts of time relies on numeracy, literacy, memory, and spatial abilities.[3] For these reasons developing concepts of time is a long-term endeavour and a “prolonged trajectory.”[4] Surprisingly, systematic and recent research on developing concepts of time is scarce and limited,[3&5] and time notation is one of the least studied mathematical symbol systems.[6]

IMPLICATIONS: Time is complex and foundational for learning within and outside mathematics, and also relies on language and memory skills

Children should learn not only to tell the time but to develop an understanding of time vocabulary, time intervals, elapsed time, and the sequencing of events

More systematic research on developing the concepts of time is needed

2

Time can be represented in many ways, including both static and dynamic: for example, as an hourglass, water flow, sundial, calendar, cycle, clock face, stopwatch (counting up), timer (counting down), timeline, storyboard, and spiral. The most prevalent is the analogue clock face; learning to tell time this way relies on mathematical ideas of counting, fractions, benchmarks, modular arithmetic ("resetting" to zero at 12 hours or 60 minutes), angle, the idea of a constant rate,[7] and reading off scales including partitioning and unitising. These ideas are used differently with analogue and digital clocks.[8] Supporting pupils in moving between a linear and a circular number line may help support development in reading clock time.[6] The use of the empty number line has been suggested to support calculating elapsed time, but it is important that, when children use representations such as clocks and number lines, they work with concepts[5] and relationships,[8] not just procedures.

IMPLICATIONS: Children are likely to encounter – and should therefore explore – a large range of representations of time, both dynamic and static

Provided the underlying relationships are also emphasised, it may be useful to move between empty number line representations and circular scales, as on a clock face

3

There has been some shift away from suggestions that children are developmentally limited by age (and therefore should be left to develop understanding gradually) towards emphasising the importance of learning and instruction: some recommendations state that time conceptions should be explicitly addressed, and taught in a systematic way.[3] However, research also suggests that the development of the concepts of time is supported by exploration, investigation, experimentation, and discovery, as well as formal instruction in measuring and reading time from clocks and calendars.[4] Encouraging children to think about time, especially duration, throughout the school day helps support their development in this area.[5] There is some limited evidence that learning to read time from digital clocks before analogue is a more effective progression than the other way around[9] (and it is certainly easier for children)[8] as well as some evidence of important interplay between the two systems of representation.[10] Moving between digital and analogue clock reading suggests the important development of connections between numerical and spatial skills.[8]

IMPLICATIONS: Explicitly addressing conceptions of time and teaching them in a systematic way is supported by some evidence, although exploration and investigation is also suggested as useful

Encouraging children to think about duration throughout the school day helps them develop intuitive concepts in this area

It may be useful for children to learn to read digital time before analogue, and moving flexibly between them is important

4

Concepts of time are difficult to teach because they are difficult to learn.[3] Reasoning with and across hours and minutes involves actions of *unit coordination* (distributing a composite unit across the elements of another composite unit),[6] and dealing with *compression points* (collapsing different types of smaller units into larger ones). Children find it particularly challenging to compose and decompose hours and minutes to solve elapsed time problems, independent of whether they use analogue or digital clock representations, and this difficulty with units has been shown typically to persist until at least age 11 – 12.[5] Language can present a particular issue when learning to tell the time; different languages vary greatly in their conceptions of, and therefore expressions of, clock time (see infographic).[11]

IMPLICATIONS: Concepts of time are difficult to teach and learn and take many years to develop

Understanding and using time involves fluency in unit coordination, and composing and decomposing units

Elapsed time problems can be particularly difficult to solve and children typically have difficulty with them until age 11 – 12

Language can present a barrier to learning clock time, related to the way that different languages conceptualise telling time

"Two aspects of time have to be distinguished in teaching: firstly, one must try to develop a concept of time in a child; and secondly, one must teach the child to 'tell the time' (teaching clock time)"

Grauberg 1998, p. 50, in Monroe et al., 2002

"Time does not easily link with the other topics of measurement due to its abstract nature: you can't go into a shop and buy a dozen minutes, or stub your toe on midday, or an hour"

McGuire, 2007

Lucy Rycroft-Smith & Lynne McClure, 2020

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