It's about time

Difficulties in developing time concepts

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examines some of the difficulties students experience with the concept of time and the telling of time.

For years, students have become frustrated with the task of learning to tell the time and teachers have become frustrated at not fully understanding why this task is such a difficult one (Monroe, Orme & Erikson, 2002, p. 475). McGuire (2007, p. 30) cites the Queensland Studies Authority in noting that "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". Considering that the clock system is "probably the least studied of the major symbol systems that confront children" (Friedman & Laycock, 1989, p. 358) and that it is "interconnected with almost everything" else in the wider mathematics curriculum (Gough, 1999, p. 191) it is easy to understand this frustration.

The concepts of time include point of time ("measured" or labelled by clocks, and calendars), and durations (measuring elapsed time) — abstract ideas about the nature of time as a flowing direction. Beyond that, most of the experiences with time in the school curriculum involve labelling, scale-conversions (e.g., minutes into seconds, minutes into hours, etc.) and translating or interpreting the use of these labels in different contexts. One of the difficulties with the labelling system is that there is no zero o'clock, just as there is no 60-minute position on a clock-dial or on a digital display.

Grauberg (1998, as cited in Monroe et al., 2002) distinguishes two aspects of time that need to be taught: the concept of time and the telling of time. The early Victorian curriculum guide (recently reissued), *Mathematics Curriculum Guide: Measurement* (Primary Mathematics Project Team (PMPT), 1981, p. 162) emphasises three main aspects of time:

- point of time;
- time intervals; and
- time span.

Point of time

Point of time refers to a specific instant in time or a precise reference point in time, which ultimately leads to reading clocks and calendars (PMPT, 1981, p. 162). Most children can read a digital clock with relative ease because "you just read the numbers" (Martin, 2005, p.13). There is a general consensus that children should be taught digital time first as this is less difficult to learn (Boulton-Lewis, Wilss & Mutch, 1997; Friedman & Laycock, 1989; Heins, 1997). This is an easy solution if the aim is merely time telling.

However, there is limited research evidence that learning to read digital time is in fact easier than learning to read analogue time. It could be argued that for reading o'clock times an analogue clock is obviously easier because all the o'clock numbers (and *only* the o'clock numbers!) are (usually) displayed. As long as the child can recognise these simple numerals, and grasps that one pointer (or hand) indicates "twelve", the other pointer shows exactly the o'clock — "that's [the child points] the time." In contrast to this, interpreting digital time — e.g., 7:00 — requires that the colon and the zeroes, and the (possible) flashing (colon, or seconds) must be ignored. Moreover, one minute later the digital display becomes more confusing!

Despite early guesses as to when digital clocks began to be widely used the analogue clock has not become obsolete with the introduction of digital time (Gough, 1999). As a consequence, students must also be able to tell the time using analogue clocks.

Tasks that students find difficult in telling the time on an analogue clock include:

- ignoring the second hand that is usually present
- understanding that hands rotate
- identifying the hour hand and understanding its meaning at, after, and before the number
- identifying the minute hand and learning to count minutes by skip counting fives to fifty five,
- learning that the minutes are superimposed on the hours and that "1" means five and "5" means twenty five
- understanding that "o'clock" follows fifty nine (or fifty five)

(Heins, 1997, p. 7)

Heins' analysis is in some ways a task analysis rather than a conceptual analysis of what is involved in the process or skill of correctly reading time on an analogue clock. As Heins (1997) and Martin (2005, p. 13) recognised, students need a considerable "bank of knowledge" in order to read an analogue clock. Furthermore, if students fail to recognise the cyclic nature of time, learning days of the week, months, years, leap years, reading the calendar and interpreting time zones may also present difficulties.

Time intervals

The term "time intervals" refers to learning about and using formal units for time, as well as the measuring and calculating durations of time (PMPT, 1981) It is the abstract, intangible nature of time (Boulton-Lewis et al., 1997), or the fact that it can be neither seen nor touched, which makes measuring and calculating time intervals difficult for students (Monroe et al., 2002).

School-age children generally have enough experience of regular events in their day-to-day life (such as meals, waking, and sleeping,) that it is not that difficult to put clock-word labels to when certain regular events (usually) occur. Teaching difficulties may arise when teachers realise that manipulative clock faces and written tasks may not be enough for developing children's understanding of the concept. To develop an understanding of the concept of time, students need to "make connections between mathematics and realistic situations" (Pace, 2004, p. 416) which comes from experience of such situations. Monroe et al. (2002) and Pace (2004) recommended using children's literature to teach both the connection between times and daily routine, and time vocabulary (such as "after," "next," "before," "night" and "dawn"). Griffiths and Clyne (1988) offer several examples of children's books that include these features, such as Anno's global multi-stranded time-zone narrative *All in a Day* (1986).

For lower attaining students, Heins (1997) recommended that teaching "seconds" and "24-hour time" is not important as these are not commonly used in everyday time telling. However since the introduction of *Windows 95*, and the massive uptake of mobile phones and e-mail, 24-hour time has become an everyday phenomenon, along with attention to time-zones in a global Internet environment.

Time span

Closely related to this is the idea of "time span", or the experience of time passing (PMPT, 1981, p. 162). According to Gough (1999), most students arrive at school on their first day with a basic, informal experience of time. This intuitive sense of time develops from children's interactions with adults and is gradually internalised by their "immersion in a timed world" (Heins, 1997, p. 6).

Heins (1997) suggests that daily word/picture schedules of school activities could be used to support lower attaining students who face difficulty with this concept. Again, children's literature such as *Working Cotton* (Williams, 1992) or Arthur's *Teacher Trouble* (Brown, 1986), can be used to teach elements of time span, such as seasons, routine, growth and decay (Gough, 1997).

Time in the mathematics developmental continuum

According to the website published by the Victorian Department of Education (2005), the Mathematics Developmental Continuum (MDC) "provides evidence based indicators of progress, linked to powerful teaching strategies, aligned to the progression points and the standards for the Mathematics Domain of the Victorian Essential Learning Standards."

However, closer inspection shows that the Mathematics Developmental Continuum provides very little evidence of the powerful teaching strategies promised with regards to time. According to the MDC (2005), at the beginning of Grade 4 (Progression Point 2.5), "Students should be able to read clocks to the hour and half hour."

In their progress to achieving Standard 3 (End of Grade 4):

> Students work to improve their use of two common measuring devices, in this case analogue and digital clocks. They also make and use simplified clocks to focus attention on one specific detail. For time, the analogue clock provides a strong visual model of time passing. First calculations of time are made using this visual model

This is clearly a "standard" or outcome-like statement, or as the Victorian Curriculum and Standards Framework used to call it, a "performance indicator", rather than a teaching strategy. Note that the last state-

ments support the argument that analogue clocks are the easier starting point.

Between Standard 3 and Standard 4, time is not mentioned. It reappears at Standard 4, however, in the form of estimating and measuring time intervals and converting between various units of time. Although it does not appear directly to address any student difficulties within this topic, it does offer some, albeit limited, teaching strategies and activities (particularly at Standard 3) that would be useful in assisting students to reach the indicators provided. For the Mathematics Developmental Continuum to adequately cover this topic, more teaching strategies and activities need to be considered for Standards 3.25 to 4 because, as Heins (1997) highlights, the average student may not have a firm grasp of time until the end of primary school.

Conclusion

From the findings presented in this article, it is evident that learning about time can prove difficult for some students, and may involve confusion around the curriculum topics of point of time, time intervals and time span. Although a number of difficulties have been identified, more research into this area of mathematics education is required to identify, in more detail, the difficulties faced by students and teachers. The teaching strategies and activities offered by the Mathematics Developmental Continuum, do not adequately address some of the student difficulties discussed in this article, however, they do provide a starting point for teachers to consider possible strategies to support students challenged by these difficulties.

Finally, consider this problem.

> Girl: "The day before yesterday I was 12."
> Boy: "But next year you'll be 15!"
> Challenge: Believe it or not, these two people are speaking the truth. On which day of which month was the girl born?
> (Pinkney, 1993, p. 44)

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