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Numeracy for Adults with Learning Disabilities: A Focus on Concepts of Time

Lorraine Gaunt

Faculty of Arts and Education, School of Education, Charles Sturt University, Port Macquarie 2444, Australia; lgaunt@csu.edu.au; Tel.: +61-2-6582-9487

Abstract: Being numerate is a vital skill for participating in the community and helps individuals to become active and informed citizens. Understanding concepts of time supports adults to organise and participate in crucial tasks, both at home and at work. This research explored how two adults with learning disabilities used concepts of time in their workplaces. Data were collected using observations and interviews to establish participants' current understandings and applications of concepts of time in their workplaces, and the numeracy demands of their work tasks. Results demonstrated that participants required deep understandings of duration and succession concepts of time to be more actively involved in their workplace tasks. The findings demonstrate the need for individuals with learning disabilities to develop abstract concepts of time throughout their learning and highlight the scant attention paid to these concepts in the school curriculum. Recommendations for how to support an understanding of these important concepts within the school curriculum are made.

Keywords: numeracy; mathematics; learning disability; intellectual disability; time; adults

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1. Introduction

One of the greater purposes of education is to prepare young people to be "confident and creative individuals, successful lifelong learners, and active and informed members of the community" [1] (p. 4). The Australian Curriculum states that "the study of mathematics is central to the learning, development and prospects of all young Australians" and that mathematics "develops the numeracy capabilities that all students need in their personal, work and civic lives" [2] (para 1). Thus, mathematics is foundational in developing numeracy which the Australian Curriculum describes as "fundamental to a student's ability to learn at school and to engage productively in society" [3] (para 1). Further, international reports highlight how numeracy, even more so than literacy, is a predictor of quality of life. For example, Tout and Gal [4] summarized results from the 2012 Programme for International Assessment of Adult Competencies [PIAAC]. In this survey, data suggested that higher levels of numeracy were associated with higher levels of quality of life indicators of health, employment, and wages. Thus, the development of numeracy is central to improving the quality of life for all adults, including those with learning disabilities. Accordingly, enacting a mathematics curriculum that promotes numeracy development for all learners needs to be promoted.

While the Australian Curriculum document states that it is "flexible, allowing schools and teachers to personalize student learning" [5] (p. 3), some researchers suggest that students with learning disabilities do not have the same opportunities and experiences with the curriculum, in particular the mathematics curriculum, as typically developing students [6,7]. Furthermore, research suggests that the way mathematics is taught to students with learning disabilities does not help them to develop conceptual understanding [8]. Instead, the focus is either on strategies to remember basic facts with number [6], or the use of algorithms to complete mathematical problems, often without developing adequate conceptual understanding [7,8]. If the aim of the Australian Curriculum is for teachers to support students in "becoming active and informed citizens" [5] (p. 1), then understanding the numeracy demands of daily activities and work-related tasks for adults with learning disabilities may help guide the pedagogy and mathematics curriculum within the classroom.

The aim of this research was to investigate the numeracy practices of adults with learning disabilities in work contexts. This paper is developed from research with four adults with learning disabilities who were observed in work and social settings and focuses on two of those adults who used concepts of time in their workplaces. Valuable insights into the teaching and learning of time concepts in schools were gained by investigating the numeracy tasks that adults with learning disabilities complete within the workforce.

1.1. Defining Learning Disabilities

It is important to define what is meant by a learning disability as it is difficult to find a consistent international definition. The Diagnostic and Statistical Manual (Version 5) [DSM5] does not provide a definition for learning disabilities but defines specific learning disorder as "difficulties learning and using academic skills, . . . that have persisted for at least 6 months, despite the provision of interventions that target those difficulties" [9] (p. 66). These students are typically described as having a discrepancy between their ability and achievement [10]. Intellectual disability is described in the DSM5 as "deficits in intellectual functions . . . as confirmed by standardized intelligence testing" (IQ < 70), and "deficits in adaptive functioning" (p. 33). While this deficit language has been challenged by some researchers [11], Australia generally follows the DSM5 definition of intellectual disability, but in the UK, individuals meeting these criteria are described as having learning disabilities. In Germany, individuals with an IQ of less than 50 are determined to have an intellectual disability and those with an IQ of 50–70 are determined to have a learning disability [11]. Different definitions of learning disabilities are often used interchangeably with other terms such as learning difficulties and intellectual disabilities, and this adds to "the fuzziness of the distinctions between terms" [12] (p. 434). Thus, with little international consensus on the definition of learning disability, it is necessary to define the term for the participants in this paper.

While in the UK and Germany, participants from this study would have been identified as having a learning disability, in Australia where this research took place, the participants of this study would usually be identified as having an intellectual disability. This definition, however, presents a deficit view of the individual, only focusing on their deficits in intellectual functioning and adaptive behaviors. The World Health Organization (WHO) defines disability as resulting from "the interaction between individuals with a health condition . . . with personal and environmental factors" [13] (para 2). The WHO perspective of disability is in line with the Biopsychosocial Model of Disability [14]. This multidimensional view of disability was beneficial for this study, as it supported the understanding of the biological impacts of disability on learning as well as the role of the context of the social, psychological, and environmental conditions, and how that impacted the learning of participants. Providing adults with opportunities to learn was the focus of this research and thus, the term learning disabilities is used for the participants in this study to avoid the deficit view of the term intellectual disabilities as defined by the DSM5 and supports the focus of research on the learning of these participants.

1.2. Numeracy and School Mathematics

While now widely understood to be the application of mathematical understanding in real life situations [15,16], the concept of numeracy has developed and changed over the last 60 years. Initially coined in the UK by Crowther and defined as "the ability to reason quantitatively" [17] (p. 282), numeracy definitions initially had a focus on functional or basic mathematical skills. Advances in technology triggered changes in conceptualizations of numeracy in the late 20th Century, and researchers questioned this focus on functional skills [18]. Broader conceptualizations of numeracy, focused on problem solving and rich tasks, emerged as a key area of research [18]. Deep conceptual understandings of mathematics are now considered important to the development of numeracy [15,16]. Building on sociocultural conceptualizations of learning, Goos [19] proposed the 21st Century Numeracy Model and further elaborated this model in collaboration with other Australian researchers [15].

From the framework of the 21st Century Numeracy Model, numeracy can be conceptualized as consisting of five elements, mathematical knowledge, tools, dispositions, context, and critical orientation. Numeracy requires mathematical knowledge, including computation, problem solving, measurement, and estimation. Numerate individuals can select and use appropriate tools to support them in completing mathematical tasks. They have a positive disposition, are willing to take risks and engage with a problem in order to make sense of a mathematical situation [15]. Numeracy is context dependent and the way in which an individual approaches a problem and the accuracy of the answer required, depend on the context [20]. The final element of the model encompasses the empowering aspect of a critical orientation to mathematical information [16]; that is, the ability to consider mathematical information critically, to challenge a position, or make a decision. Steen [20] describes this ability to be able to "confront authority confidently" (p. 2) as the essential "skills to thrive in the modern world" (p. 2). A critical orientation to numeracy has come into focus recently in light of the COVID19 pandemic with Roozenbeek et al. [21] undertaking a study across five countries (UK, USA, Spain, Mexico and Ireland) between April and May 2020 examining predictors of belief in statements containing misinformation about the virus. They found that individuals with higher numeracy skills were less likely to believe misinformation about COVID19.

Numeracy is a vital skill for all adults and developing a numerate population begins with the school curriculum. A challenging mathematical curriculum with a focus on problem solving and rich tasks is required with attention paid to mathematical concepts across the curriculum [22]. In Australia, numeracy has been a cross curriculum priority in the Australian Curriculum since its inception [23] and in the recent revision of the Australian Curriculum, the numeracy progressions have been incorporated into the numeracy general capability [3]. In this new revision of the mathematics curriculum, it is recognized that mathematics is crucial to the development of numerate citizens [2].

Research suggests that typically developing students are afforded opportunities to engage with challenging and relevant mathematics curriculum likely to support the development of numerate individuals [24,25], but despite legislation supporting inclusive and equitable access to education [1,26], learners with learning disabilities are typically exposed to a narrow range of mathematics curriculum. Bowman et al. [27] conducted a systematic literature review of mathematics instruction for students with moderate to severe disabilities (IQ < 60) from 2005 to 2017. Of the 24 included articles coded using the National Council of Teachers of Mathematics [NCTM] content strands of number and operations, algebra, geometry, measurement, and data analysis and probability, 18 studies (75%) researched in the area of number and operations and only one study (4%) investigated data analysis and probability. Further, 38% of studies investigated algebra, 21% geometry, 25% measurement with 33% of studies investigating more than one area. The significantly high proportion of studies investigating the concepts of number and calculation show little broadening of the research since previous systematic reviews where research [28] showed 40% of studies involved number and operations and 53% involved basic skills of money and time.

Some researchers suggest there are two reasons that students with learning disabilities are not exposed to a broad range of mathematics curriculum that would support them in becoming numerate adults [8]. First, a "utilitarian view of mathematics" [8] (p. 187) in which the mathematical topics of importance are those that concentrate on supporting students' ability to function in society. Hence, mathematics is studied "in order to understand the world quantitatively" [8] (p. 187) rather than learning mathematics to reason and communicate in a mathematical sense. Second, mathematics is considered to be a hierarchical subject [8] in that more complex mathematics cannot be taught without a firm understanding of earlier concepts. Arithmetic and number are thought to be the foundational concepts that all students need to understand [29,30] and students with learning disabilities often spend the majority of their schooling trying to master these foundational concepts [31], to the detriment of learning a broad mathematics curriculum.

More recently, researchers [6,31] have challenged this idea advocating for a broad range of mathematics topics to be included in school mathematics curriculum "to prepare students for a numerate adulthood" [6] (p. 210). This can be accomplished by teaching a range of different topics alongside each other, learning in a parallel way rather than sequentially [31], as this allows students with learning disabilities the opportunity to experience a broader range of mathematics topics. Explicitly teaching the efficient use of tools to support learners with basic mathematical tasks such as calculation is essential to supporting access to a broad mathematics curriculum for learners with learning disabilities [6,32].

If teachers, guided by the Australian Curriculum Mathematics, are to focus on supporting the development of numerate students, it is important to identify the aspects of mathematics that should be included. As yet, we have little detail about the numeracy required by adults with learning disabilities when they enter the activities of adult life and the workforce. In a study involving 11 adults with learning disabilities, the numeracy practices of adults in daily activities during work, education, living, and free time contexts was observed [11]. In their findings, the researchers highlighted the "abilities, meanings, and events" (p. 589) that demonstrated existing numeracy practices of adults with learning disabilities, often ignored by traditional research methods. The researchers observed adults demonstrating competency in a range of mathematical concepts as they completed daily activities such as folding napkins at right angles which demonstrated understanding of geometry concepts. Another participant recounted strategies they had learnt to change the time on their alarm clock (different to the actual time) to try and make them get out of bed in order for them to get to work on time. The discussion demonstrated how the participant used the mathematical understandings of time in order to manipulate a tool and support their development of time management skills. This small scale study identified the benefits of observing adults with learning disabilities in the context of the activities they complete on a daily basis and researchers were able to uncover evidence of numeracy in everyday activities. The numeracy involved in everyday activities is inextricably intertwined with the goals, purposes, and social context in which the activity takes place and for adults, "has the potential for empowerment, even emancipation" [33].

To support the development of adults with learning disabilities as learners of mathematics and numerate individuals, further research incorporating the voice of adults with learning disabilities, focusing on their uses of mathematics in everyday contexts is needed. In this paper, the numeracy practices of adults with learning disabilities in work contexts involving the use of time were investigated. Adults' experiences of learning time concepts at school may impact on their ability to apply those concepts in the workplace.

1.3. Time, Calendars and the Australian Curriculum

The research reported in this paper focuses on the practical application of the concepts of time within two workplaces. Time is a complex measurement concept as it is abstract and cannot be touched and manipulated [34]. An understanding of time allows adults to interact with the world around them in a meaningful way, and to plan and organize activities in order to complete all required tasks within an appropriate time frame [35]. Thomas et al. [36] developed a framework that could be used as the basis for teaching concepts of time. Four aspects were identified:

- Awareness of time: understanding a point in time and the language of time;
- Succession of time: the ability to order events and understand concepts such as the past, present, and future;
- Duration of time: the ability to compare and measure the passing of time;
- Measurement of time: reading clocks and calendars, and understanding units of time.

To support the development of numerate citizens who are able to implement their knowledge of time in useful ways, teachers, guided by the Australian Curriculum Mathematics, should develop students' understanding of time across all of these concepts throughout schooling. In 2014, Thomas et al. [36] examined the curriculum of Australia, England, Singapore and the USA and found limited focus on the concepts of succession and duration but a strong emphasis on awareness and measurement of time in the curriculums of these countries.

The new version of the Australian Curriculum released in 2022 has shown little change in the concepts of time covered since 2014. The foundation year focuses on awareness of time concepts such as comparing and ordering familiar events using informal language of time and linking the calendar with days of the week. As students progress through the early primary years, they develop skills in indirect and then direct measurement of time, and progress from using informal units of measurement to standardized units of measurement. For example, reading the time to the half hour begins in Year 2 and progresses to reading the time to one-minute intervals by the end of Year 3. Using the calendar to identify specific dates and events is taught in Year 2 with the main focus on measurement aspects of time, not succession. In Year 4, duration of time is studied but with a focus on calculations and Year 6 covers succession and duration with students expected to apply their knowledge of time to using timetables and planning events. Limited focus on time is identified in the secondary curriculum with Year 8 content descriptors including calculations involving 24 h time and Year 9, calculations of very large and small time scales. Although the Australian Curriculum now uses the language of succession and duration within some of its content descriptors (a change since Thomas et al.'s [36] 2014 investigation of the Australian Curriculum), the focus of most of the content is still heavily concentrated on measurement of time aspects. Without a clear understanding of the more difficult and less tangible concepts of duration and succession, students leaving school, particularly students with learning disabilities, may struggle to develop a sound understanding of the concepts of time.

It is often assumed that adults have an understanding of time [37] and if adults with learning disabilities have difficulties, this fact may go unnoticed and may affect their opportunities at work. To determine the impact of understandings of time concepts on opportunities at work, an understanding of how adults with learning disabilities currently use time within the workplace is required. Thus, this study investigated the research question: How do adults encounter and engage with time concepts within the numeracy demands of their daily work tasks? This paper focuses on the numeracy demands of work tasks involving time. Ways of supporting these adults with learning disabilities is the focus of other publications for example [32].

2. Materials and Methods

This research used four individual case studies to analyze participants' numeracy in a variety of contexts. In two cases, participants needed to apply concepts of time as part of their work tasks and their experiences with time are reported in this paper. Ethical clearance for this study was obtained from the University of Queensland (approval number 2013000802). In this section, the research design, data collection instruments, participants, work settings, and techniques for data analysis are detailed.

A qualitative, multiple case study research design [38] was chosen using observations to document numerate behaviors and interviews to give participating adults an opportunity to have their voices heard about the numeracy needs and interests of importance to their work activities. Five to seven audio-recorded observation sessions were conducted at each participant's workplace (see Table 1). Additionally, audio recorded interviews with participants and significant others (see Table 1) were completed after the observations, and fieldnotes and copies or photos of participants' work were collected.

Table 1. Observation and interview schedule.

Participants (Pseudonyms)	Observations		Interviews
David	7 Observations in 7 weeks	$1\frac{1}{2}$ h each	1. David 2. Lisa (Support worker)
Ellen	5 Observations in 3 weeks	1–2 h each	1. Ellen 2. Mother

Taking on an observer participant role [39], the researcher observed the participants completing their activities but also interacted with participants and others to clarify observational interpretations. This allowed the researcher to gain insight into the conversations and activities that participants were having as the completed the numeracy demands of their tasks and allowed the researcher to gain immediate insight into task complexities and difficulties. Using an observation protocol allows for the systematic collection and clear recording of data and adds to the reliability of the data [40]. The observational protocol used in this study included a description of the physical setting and environmental factors on one side of the page and details of the activity on the reverse side. A column was used to record the chronological order of the activity allowing the researcher to note details about the numeracy demands of the activities in each observed context. Initial codes, based on elements of the Numeracy Model (see Table 2 for some examples of codes) were recorded in an adjacent column. To enhance the observational data, photographic data were also collected. Photographs captured images of interactions or artefacts during the activities and were used to develop supports for the interviews.

Table 2. Data Code Examples.

Code	Subcode Examples		Example
Mathematical Knowledge (MK)	MK-s	Succession (time)	Ellen: [Looking at the next booking sheet] That one is for August, that is after July. (Observation 3, Office)
	MK-d	Duration (time)	David: It’s 11:28, nearly 11:30. Lorraine: How much longer do we have? David: Don’t know (Observation 3, Restaurant)
	MK-m	Measurement (time)	David: [checked his watch] It is 12:10. (Observation 1, Restaurant)
	MK-c	Capacity	David: See you just fill it up to here [indicating where to fill the tray up to with chips], and then you shake them out [demonstrating how to level the chips in the tray by shaking it back and forth] and then you put the lid on, and you are done [proudly showing completed tray]. Me and [worker 2] have been doing this longer than [worker 1] so we don’t need to use the measuring container anymore, we know how many chips to put in. (Observation 1, Restaurant)
	MK-mn	Matching numbers	Ellen: [filing documents by matching vehicle registration numbers] I can’t find 494. [finding tab in the folder] Oh there it is, this one goes in there. (Observation 3, Office)

Table 2. *Cont.*

Code	Subcode Examples		Example
Mathematical Dispositions (MD)	MD-i	Initiative	[The two other workers finished putting their chips in trays, but their last trays were not full] David: Why don't you put the trays together and then you will have one full tray. (Observation 4, Restaurant)
	MD-h	Willingness to help	[A worker had only half filled a tray with chips] David: That isn't full, you need to fill that all the way to the top first [worker filled tray] David: Now you've got it, keep doing that (Observation 5, Restaurant)
	MD-l	Eagerness to learn	Ellen: I've been here 5 years. I've done this for 5 years and I just want to learn to do more things (Observation 3, Office)
Mathematical Tools (MT)	MT-p	Physical	No codes in the first phase of this study
	MT-r	Representational	Calendar
	MT-d	Digital	Digital watch
Critical Orientation (CO)	CO-md	Making decisions	[A worker asked if it was time to start cleaning up] Lisa: What's the time David? David: 11:47 Lisa: [to other worker] No, you need to do more chips first (Observation 2, Restaurant)
	CO-re	Recognising errors	[Ellen's supervisor had filed a booking sheet in the wrong date order in the folder] Ellen: [reading the dates] 24, 29, 27 [pause] that isn't right! (Observation 1, Office)

To verify and validate assumptions made by the researcher from the observational data, interviews with participants and significant others were conducted (See Table 1). The reliability of interview data collected with individuals with learning disabilities has been explored in the research [41–43]. To support adults with learning disabilities in understanding interview questions and explaining their answers, the use of visual resources [43] and providing relevant contextual information [42] have been recommended by researchers. Bains and Turnbull [42] suggested the value of previously gathered data to contextualize and guide the participation of adults with learning disabilities in self report data such as interviews. Following the observations, visual resources were developed, using photographs taken during observations, to support adults in answering interview questions. Research [43] has shown that if the researcher asks clarifying questions, as in a semi-structured interview format, and makes use of visual resources and contextual information responses from adults with learning disabilities form reliable data. In this study, interviews with participating adults and significant others such as support workers or parents, were used to verify, and validate researcher interpretations of events during the observation sessions.

2.1. Participants and Their Work Settings

To protect participant anonymity, pseudonyms are used. David is a 41-year-old Caucasian male with learning disabilities, who lived in supported accommodation. David enjoyed ten-pin bowling and music and could almost always identify the song and the band playing on the radio at work. He attended a day-service, disability-support center, four days per week. On one of those days, David and two other individuals with learning disabilities volunteered at a local fast-food restaurant, with a support worker, Lisa. They completed a one-and-a-half-hour shift where they sorted chips and garlic bread into trays ready for the oven. David's work in this setting was observed seven times over seven weeks for the full shift.

Ellen is a 24-year-old Caucasian female who has Down syndrome. She enjoys ballet, acting and craft and actively participated in these pursuits, including performing in both local and larger productions. On two mornings per week, Ellen volunteered at an office which provided aged care support for individuals living in their own home. Ellen worked independently in this position (without a support worker). One of Ellen's tasks was to file booking sheets in the medical transport bookings folder. Ellen's work in this setting was observed five times over three weeks Observation sessions lasted one to two hours, depending on the length of time taken to complete the filing task.

Gaining Informed Consent

According to the National Health and Medical Research Council [NHMRC], informed consent is required from all participants for research. The NHMRC states that consent should be sought from an adult with learning disabilities if they have capacity to do so. They also suggest that another adult, not associated with the research, may be present during the consent process to support the adult with learning disabilities in understanding what is required of them.

The difficulties of gaining consent from research participants with communication and learning disabilities has been highlighted [44] and working with the participant's support personnel to determine if the individual wanted to consent to be a part of the research is one suggestion to support informed consent. Questioning adults with learning disabilities to determine their capability of providing informed consent is another suggestion from the research [45]. which supports adults with learning disabilities in having agency over their own choices. For this study, participants were asked to explain the study in their own words and why they wanted to participate. Based on their responses, both David and Ellen demonstrated capability in providing informed consent, however, they were given the choice of bringing a support person to the initial meeting if the wished. Ellen chose to bring her mother as a support person and her mother observed the consent discussion but did not intervene. David chose to attend the meeting independently. After having the research explained to them, and their freedom to withdraw at any time, both Ellen and David provided informed consent and remained part of the study for the duration of the research.

2.2. Data Analysis

Data analysis commenced with writing observer comments on field notes of observations and interviews [39]. Coding is "assigning some sort of shorthand designation to various aspects of your data so that you can easily retrieve specific pieces of the data" [39] (p. 199). Initial coding of data was based on the 21st Century Numeracy Model [15] (Mathematical Knowledge (MK), Mathematical Dispositions (MD), Mathematical Tools (MT), Critical Orientation (CO)), as seen in Table 2, in line with the coding reliability approach [46]. This form of coding is appropriate when the framework drives the coding process.

However, qualitative data analysis should include an inductive component [39,46]; that is, codes should develop from the data. Whilst the initial deductive coding was useful in helping to organize the data into broad categories of the numeracy model, an additional round of coding was required to develop more refined codes from the data.

This second round of coding was both deductively and inductively developed from the analysis of the transcripts. For example, some codes inductively developed from the data including MK-c, capacity, MK-nm, number matching (see Table 2 for an example of these codes). Where participants demonstrated concepts of time these were originally coded MK-t. As these concepts of time became overwhelmingly evident in the coding (71% of MK codes for David were MK-t and 81% for Ellen), mathematical knowledge associated with time was further coded deductively using the Thomas et al. [36] time framework with codes used for succession of time (MK-s), duration of time (MK-d), and measurement of time (MK-m). As all incidents included an awareness of time, this aspect of the model was not coded. Another example of inductive coding is represented by the coding of different dispositions which became evident during the research, for example initiative (MD-i), willingness to help others (MD-h), and eagerness to learn (MD-l). Codes inductively developed from the data (Table 2) illustrated commonalities that become visible in the accumulation of different observations.

The two rounds of coding were completed after each observation. New data from each observation were added chronologically and compared to previous interpretations and conjectures to either affirm or deny the conjectures. Similarly, when interviews were completed after the observations, that data were coded, added and compared to the interpretations developing from the observation data. This general approach to data analysis is consistent with the constant comparative method originally described by Glaser and Strauss [47] and refined by Cobb and Whitenack [48] for use when analyzing longitudinal classroom transcripts. For example, initial observations of David's workplace highlighted the frequency and accuracy of his ability to tell the time. As observations progressed, this ability was confirmed and his willingness to support his fellow workers in their tasks became apparent. This led to conjectures about possible opportunities to make decisions in his workplace.

3. Results

The findings reported here demonstrate the depth of understanding about concepts of time required by participants in their work activities. The initial data coded as MK for David included 1% of codes related to division, 3% to ordinal numbers, 5% to capacity and 71% of data coded as MK related to concepts of time. For Ellen, 6% of MK data coded related to counting, 10% to matching numbers, 3% to reading numbers, with 81% of data coded as MK for Ellen related to concepts of time. This indicated the importance of concepts of time for both participants in these workplaces and therefore, the focus on time for research with these two participants. The data showed that both David and Ellen were competent with concepts of measurement of time, but although an understanding of succession and duration of time were evident as being necessary in their workplaces, the participants were not as successful at these tasks. Using transcript data, the participants' strengths in concepts of time are explored further in the next sections.

3.1. David: The Fast Food Restaurant

During observations at the restaurant, David consistently told the time accurately on his digital watch to one minute (this was observed 27 times). On six occasions, he converted the time accurately to analogue time and he rounded off the time to the nearest five minutes on five occasions. David completed these tasks correctly on every occasion he was observed to attempt the task. The following transcript excerpt (Transcript A) demonstrates his skills with telling the time.

Line 1	*David*	[checking his watch] *Look at that, it is finish time.*
Line 2	*Lorraine*	*What time is finish time?*
Line 3	*David*	*12:30.*
Line 4	*Lorraine*	*Oh. Is it 12:30 now?*
Line 5	*David*	*No, it's a bit early, it's 12:26 but that's nearly half past. We get pizza now.*

Transcript A: The Restaurant Observation 1.

David demonstrated strength in telling the time, converting between analogue and digital time, and rounding off time to the nearest five minutes (see lines 3 and 5 above). However, on the seven opportunities that David had to demonstrate an understanding of the duration of time, he answered correctly only once, and the tentative nature of his response indicated that it was a guess, as can be seen by Transcript B.

Line 1	*David*	*It is 11:59, almost 12 O'clock*
Line 2	*Lorraine*	*So how much time [of the shift] is left?*
Line 3	*David*	*Oh . . . Um [tentatively] half an hour?*

Transcript B: The Restaurant, Observation 4.

This uncertainty about duration of time was supported in David's interview at the end of the observation phase. When asked how long his shift at the restaurant was, David answered "*It's from 11 am and we finish at 12:30, it's about an hour*". In the interview, David also described catching the train to visit his sister (see Transcript C).

Line 1	*David*	*I walk across the bridge and go down an elevator and she normally just umm . . . and then I would walk to the Pat Rafter tennis courts and she would pick me up from there*
Line 2	*Lorraine*	*How long does that take to walk*
Line 3	*David*	*About an hour, but sometimes I ring her from the train and then I just walk across the bridge and go down an elevator and she picks me up*
Line 4	*Lorraine*	*How long does that take to walk*
Line 5	*David*	*Half an hour I reckon*

Transcript C: Interview with David.

A Google Maps search reveals that the walk from the train station to the tennis courts takes 18 min, although in line 3 of the transcript David indicated the trip was about an hour, and only a few minutes would be required to walk across the platform bridge to meet his sister, but David indicated this would take 30 min (line 5). During the interview, David was asked seven questions that required a response about the duration of time. He responded correctly on only one occasion, the time taken for him to complete his exercise routine from 4 pm to 5 pm, "*That's an hour*".

3.2. Ellen: The Office

At the office, Ellen filed documents into folders in date order. The following observation transcript excerpt (Transcript D) demonstrates Ellen's initial skills in filing dated documents. The dates written on the documents were in different formats, for example, 19/8, 19th August, August 19 or 19/8/2018. From the first observation, Ellen demonstrated that she was able to read dates written on booking sheets in all of these formats with 100% accuracy. Ellen's interest in and competence in reading and remembering dates was supported in the first interview where she stated "*I know all the important dates, like concerts and things and my friend's birthdays, and you know there is someone special coming up with birthdays, MINE [provides birthdate: Date, Month] and [friend] is on [date, month]*".

Ellen correctly read dated material (measurement of time) in different formats with 100% accuracy as demonstrated in lines 2 and 4. However, she demonstrated difficulty in identifying where the new dated document fit within the sequenced dated documents (succession of time) already contained in the file (see line 6). Out of the 23 documents, Ellen filed during this session, only nine were independently filed in correct date order. To be able to sort documents in date order and then identify where a new document fits within previously chronologically filed documents, is an application of succession of time, the ability to order events [36], but also relies on other mathematical skills such as ordering numbers.

Ellen demonstrated strengths in counting and ordering numbers (for example see Line 8 of Transcript D), and in ordering familiar events in date order. For example, she knew where her upcoming birthday was situated in order with other friends' birthdays and significant events in her life such as her drama concert. On these occurrences, it is likely that the familiar context supported her understanding of the order of these events. When asked to order documents in date order, in absence of any familiar context, Ellen needed to rely on her understanding of the date which involves ordering three time aspects, the day, the month and the year.

Line 1	*Lorraine*	*What are you going to do first?*
Line 2	*Ellen*	*Well, this sheet* [taking the top document from the pile] *is for August, the 19th.*
Line 3	*Lorraine*	*Can you show me where it needs to go in the file?*
Line 4	*Ellen*	[Looking through the folder for some time going backwards and forwards searching for a similar sheet.] *This is an August one, this is 14th August* [Ellen flips the next sheet in the folder] *and this next one is 21st* [Ellen flips the next sheet in the folder] *and then this one is 23rd.*
Line 5	*Lorraine*	*So, where do you think 19 August goes?*
Line 6	*Ellen*	[Flipping the top sheet (the 23rd) back in the folder and pointing to the place between 21 and 23] *in here?*
Line 7	*Lorraine*	*Look at the numbers if it goes there.* [Flipping the sheets in the file back to the 14th] *say the numbers from here.*
Line 8	*Ellen*	[flipping the sheets in the file one by one and reading out the dates] *14, 21, 19, 23. That doesn't sound right.* [counting to herself softly] *14, 15, 16, 17, 18, 19, 20, 21, 22, 23; ah ha, it should be here* [pointing to the place between the booking sheets dated 14^{th} and 21^{st}].

Transcript D: The Office, Observation 2.

3.3. The Impact of Participant Understanding of Time on Work Roles

While Ellen and David demonstrated strengths applying concepts of measurement of time, both participants demonstrated difficulties with concepts of succession or duration. A greater understanding of these concepts would support David and Ellen in their workplaces. For Ellen, her limited skills in ordering documents in date order made accurately filing dated material a difficult task. This meant that another employee had to place the documents in the correct place in the folder and Ellen's task was reduced to one of simply using the hole punch. However, Ellen was keen to learn this skill as demonstrated by her response to the offer of support in learning how to file independently (coded as Eagerness to learn): "*Oh yes, that would be so cool. Then my boss doesn't have to do it for me, and I will get more work to do*" (Observation 2). During the study, there were 10 statements coded as mathematical dispositions (MD) for Ellen, as shown in Table 2, and eight of these responses were coded as eagerness to learn (MD-l). During the first interview, Ellen again confirmed her interest in learning how to file the material in date order when she said "*I want to learn to do my filing job so my boss doesn't need to help me. I want to be able to do it on my own, then she* [my boss] *will be proud of me*".

While Ellen demonstrated a willingness to learn, the data demonstrated the difficulties that Ellen faced with this task. When confronted with a problem in a novel context, Ellen did not have strong enough mathematical knowledge of succession of time concepts or sufficient skills in problem solving to tackle the task. In Transcript D, Ellen can be seen struggling to find the correct place to file the dated document in lines four and six. During the observations, 55% of incidents coded as MK-s (see Table 2) were incidents where Ellen had difficulty with filing dated documents in the correct date order in the folder. Greater understanding and support for concepts of succession of time would support Ellen in working independently on this task.

For David, his understanding of the duration of time limited his ability to engage with different tasks in this workplace. The following transcript excerpt (Transcript E) demonstrates the potential for empowerment if David could further develop this skill. At the restaurant, it was Lisa (the support worker) who made decisions about the progress of the shift. While always asking David the time, Lisa made decisions based on his answer.

Line 1	Lisa	*What time is it buddy* [David]?
Line 2	David	[checking his watch] *12:07.*
Line 3	Lisa	[talking to herself] *How many* [garlic bread] *are left.* [3 boxes plus the current one] *I had better do one of these*
Line 4		Lisa completed a box of garlic bread to ensure they finished on time.

Transcript E: The Restaurant, Observation 3.

Whilst David was involved in this interaction by answering Lisa (line 2), he was not involved in making any decisions based on the time (line 3). Lisa made the critical decision that the workers were not going to finish all of the remaining boxes of garlic bread in the time left on the shift. Similar situations regarding Lisa making these types of decisions occurred seven times during the study. In each instance, while David provided the time, the critical decision was made by Lisa.

David did demonstrate initiative, a willingness to help, and the ability to make some decisions and take a leadership role in the workplace (see Table 2 for coding examples). For example, when another worker had not filled a chip tray sufficiently, David said "*That isn't full, you need to fill it all the way to the top*", or when another worker thought that they were ready to start sorting the garlic bread, "*No, remember we have one more box of chips to do first*". David supported his fellow workers and made similar decisions on 11 occasions during the study. By improving his understanding of duration of time, David may have the opportunity to make further decisions in his workplace and take on a leadership or mentoring role with his fellow workers.

David and Ellen demonstrated strengths in relation to the measurement of time, but the numeracy demands of the tasks that they were undertaking in their workplace required an understanding of succession or duration of time to allow them to be more independent and productive in that setting. These findings of the numeracy demands of workplace tasks can provide information to support the way time concepts are covered within the classroom for students with learning disabilities to support their development towards becoming numerate citizens once they leave school.

4. Discussion

Adults need deep conceptual understandings of time, an understanding that goes beyond just an awareness of, and measurement of time; beyond the ability to read a clock or calendar. An investigation of the current Australian Curriculum concurred with previous investigations of curricula by Thomas et al. (2016) in that curricula emphasized students' developing an awareness of time, and skills with the measurement of time, but were limited when it came to emphasizing the concepts of succession and duration.

David demonstrated significant strengths in measurement of time such as reading. time in analogue and digital formats and converting between these formats. Yet, even with these significant skills in measurement of time, David struggled with any aspects of his role that required concepts of duration of time. He could not estimate how long tasks might take, identify how long he had been working in his shift or how much time there was left on his shift, skills that would have supported David in actively participating in tasks such as time management of the shift. David's interaction with his work colleagues demonstrated his potential to mentor and support his peers and supporting David's continued development of concepts of time may allow David this opportunity to continue to progress in his work setting. Succession and duration of time concepts are more abstract and complex [36] but need to be developed to support full participation in everyday tasks.

Ellen demonstrated strong measurement of time skills in accurately reading dated material in all different formats but struggled with succession of time tasks that required her to sequence dated material. The filing of the documents for Ellen was a complex task involving sequencing the month part of the date, sequencing the day part of the date and also finding the correct place amongst previously filed dated material. These complexities of the task combined with Ellen's limited fluency in succession of time concepts (see line 8 of Transcript D), made the completion of the task too difficult, although Ellen clearly demonstrated her desire to continue to learn and develop independence in her work tasks, as can be seen from her interview and observation transcripts. While Ellen had mastered skills of measurement, more complex time tasks had proved difficult. Many students with learning disabilities lack opportunity at school to develop conceptual understanding of more complex mathematical tasks as the focus of their curriculum is the development of basic concepts [8]. Findings from this study support the research of Thomas et al. [36] and demonstrate the importance of a holistic understanding of time, including duration and succession concepts and the importance of these to active participation in work activities. It is possible that both David and Ellen would have benefited from more opportunities to problem solve at school with more complex tasks involving time which may have supported them in applying their well-developed understandings of measurement of time to concepts of duration and succession tasks in novel situations.

Implications for School Curriculum

While the Australian Curriculum, and many other curriculums around the world have a strong emphasis on measurement of time, there is a need to increase the emphasis on the other concepts of time, the more abstract and complex concepts of duration and succession. Similar to work completed by Hopkins and Donovan [7], teasing out tasks for duration and succession concepts to develop a progression of tasks that gradually increases in complexity over the primary school years and into the secondary school, could support students to develop deeper understandings of these concepts. David and Ellen have demonstrated that individuals with learning disabilities can develop deep understandings of time concepts as indicated by the strengths in measurement of time. Access to the same opportunity to develop skills in succession and duration can be provided if more detailed examples of these concepts are included in the Australian Curriculum throughout primary and secondary levels.

Further, Faragher [6] highlighted the importance of attending to the wider mathematics education research literature to evaluate possible ways of supporting students with learning disabilities in preparing them to be "learners for lifelong numeracy development" (p. 209). Problem solving in mathematics [49,50] and the design and use of tools [51] has been highlighted in the research literature to engage and support students in developing conceptual understanding of mathematics topics. Supporting students with learning disabilities and providing opportunities to work on the concepts of duration and succession of time in a variety of problem-solving tasks, may provide further strengthening of these students' understandings of time concepts.

Thomas et al. [36] reported that teachers indicated duration and succession of time, were often taught informally in the classroom rather than formal lessons with a specific focus on these concepts. While there are topics within the Australian Curriculum across primary and secondary levels that relate to succession and duration concepts, and the language of duration and succession are now used withing the curriculum document, broader recognition within the Australian Curriculum is required to support teachers in implementing a more structured approach to the teaching of these important concepts of time. The findings of this study support the research of [36] and extend the findings to demonstrate the need for an understanding of concepts of duration and succession in the workplaces of two adults with learning disabilities.

5. Limitations

This was a small-scale study only investigating four cases, and only two reported in this paper, and thus the findings are not easily generalizable. However, these results support the research of Thomas et al. [36] and extend the importance of succession and duration of time concepts to adult life. While this research identifies areas where the Australian Curriculum could be further developed to provide more extended study of concepts of succession and duration of time, further research is required to design these suggested changes.

6. Conclusions

While only a small scale study, the findings support those of Thomas et al. [36] and indicate that to support the development of numerate adults, particularly adults with learning disabilities, specific attention to succession and duration concepts is required within both primary and secondary classrooms and continued opportunities to learn post school are needed. Commonly, the focus in primary classrooms is on awareness and measurement of time with limited focus on succession and duration in either primary or secondary settings.

In their workplaces, Ellen and David did not have the opportunity to learn mathematical knowledge in the contexts in which they were working. Learners with learning disabilities often demonstrate difficulty in transferring knowledge to new and novel settings [6,27]. Thus, it is important for trainers and employers to continue to provide adults with learning disabilities the opportunity to continue their learning post school.

While David demonstrated strengths in measurement of time, his lack of understanding of duration of time, meant that he lacked the opportunity to use that knowledge to make critical decisions in his workplace and thus become a leader amongst his peers with greater responsibility in his work tasks. While Ellen demonstrated strengths in measurement of time, her lack of understanding of succession of time reduced her task of filing to one of hole punching and placing documents in predetermined positions of a folder. Improving her skills in this area would give her the opportunity to become more independent and have greater responsibility in her work tasks. Increasing independence and responsibility for adults with learning disabilities has the potential to empower them and improve their quality of life.

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