Designing Individual Goals to Enhance the Numeracy of Adults with Intellectual Disabilities

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Design research (DR) methodology is often used to investigate the mathematical learning and trial the means of supporting it. We report on data from a larger DR study, in which we investigated how adults with intellectual disabilities (ID) continue to develop their numeracy in everyday activities. Previous analysis of data from this study indicated that adults with ID demonstrate numerate behaviour in the tasks they complete every day. We first discuss our conceptualisation of participants' numeracy learning; then draw on data collected through observations and interviews to illustrate how we designed viable individualised numeracy learning goals for adults with ID that were empirically, as well as theoretically informed.

The overarching premise in this paper is that understanding the potential for continuing learning of adults with intellectual disabilities (ID) and how this learning can be proactively supported is of considerable pragmatic interest, because resulting increased independence of learners can significantly enhance quality of their lives. The research presented in this paper was guided by specific conceptualisations of numeracy and disability. We first introduce these conceptualisations and how we combine them in conducting the study. We then foreground the methodology before presenting evidence of the importance of designing individual goals to support further learning in numeracy for adults with ID.

A Conceptualisation of Numeracy

Numeracy has been a focus of educational policy in Australia and internationally in recent decades (Department of Education, Employment, Training and Youth Affairs (DDETYA), 1997). Numeracy is a recent addition to education language, initially appearing in the Crowther Report (Ministry of Education, 1959) and defined as "the mirror image of literacy" (p. 270). Crowther was the first to suggest that numeracy was more than just school mathematics; it was an ability to act, think and apply mathematics in everyday activities.

Since this term was first used, the conceptualisation of numeracy has continued to evolve and there has been continued debate about what constitutes numeracy (Cockcroft, 1982; The National Council on Education and the Disciplines, 2012). In Australia, the DDETYA (1997) defined numeracy as to "use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic live" (p.15).

Goos (2007) suggested that in the current context of rapidly evolving technology, work and social structures, a broader, socially situated approach to numeracy was required. She proposed a model which highlights the importance of learning contexts, and emphasises that numeracy is not constrained to mathematical knowledge, but includes learners' dispositions, reasoning tools, and a critical orientation towards ways in which mathematics is being used in making sense of problem situations (See Figure 1, Goos, Geiger, & Dole, 2012).

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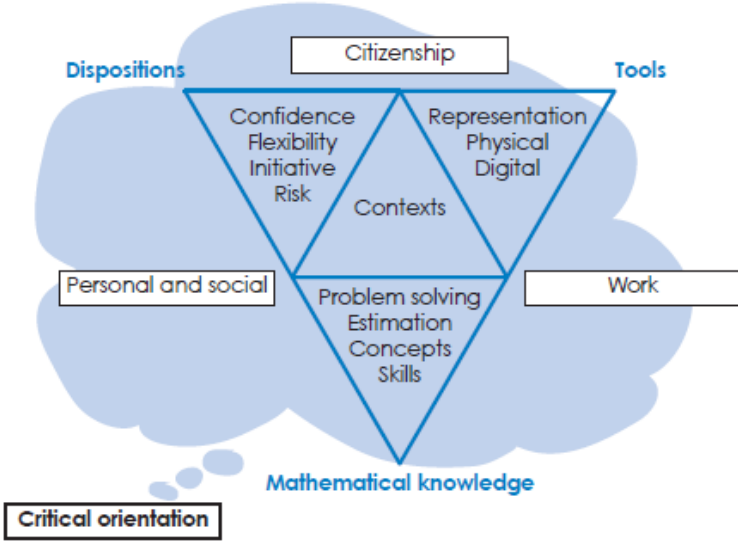

Figure 1. Numeracy Model (from Goos et al., 2012, p. 4).

The numeracy model recognises that *mathematical knowledge*, beyond calculation skills, encompasses also proficiencies such as problem solving and habits of mind such as estimation. Goos et al. (2012) suggest that a numerate person has a *positive disposition* towards numeracy and is willing to use mathematical skills rather than avoid situations that require mathematics. A numerate person would thus be inclined to draw on mathematical knowledge in different *contexts* when solving problems and making sense of information. In doing so they would select and use appropriate physical, digital and representational *tools*, and adopt a *critical orientation* to numeracy, that is, the inclination to critically evaluate and make judgements about appropriate uses of mathematical tools to gain insights into the problem at hand.

Adopting this perspective, we view numeracy of an individual as their participation in a complex practice that is situated in the specific context, reliant on their mathematical knowledge, the tools available, the developed disposition and the extent to which they adopt a critical orientation (cf. Goos, 2007). This numeracy model, combined with the conceptualisation of disability we now introduce, provided the framework we used to explore the numerate behaviour of adults with ID.

A Conceptualisation of Disability

Understandings of ID have changed over time according to the philosophical viewpoints of different theoretical models of disability (Connor & Gabel, 2013). These different models, including the medical, social and biopsychosocial models of disability, influence policy, legislation and ultimately community attitudes towards individuals with a disability.

Disability within the medical model was conceptualised as a medical, physical or psychological defect or problem which is intrinsic to the individual (Falvo, 2014). From this perspective, disability focuses on the development of treatments and solutions to eliminate the disabling condition and return the individual to 'normal'.

With this one-dimensional view of disability, negative definitions of ID were common. Edouard Seguin's 1846 definition classified people with ID as 'idiots, imbeciles and morons' (Mutua, Siders, & Bakken, 2011). In 1959 the American Association of Mental Retardation (AAMR) defined 'mental retardation' as "subaverage functioning" and "impaired adaptive behavior" (Heber, 1959 as cited in Scheerenberger, 1987, p. 11).

Instead of viewing disability as intrinsic to the individual and something that needed to be cured, the social model of disability views the environment and society as barriers (Thurman & Fiorelli, 1979) and suggests that changes in these would include people with disabilities in society. However, by overemphasing social aspects and, failing to recognise the impact of the impairment on the disability, like the medical model, the social model is one-dimensional in its viewpoint (Reindal, 2008).

In our study, we adopted a model which encompasses the social impacts of disability and recognises the impact of the impairment- the biopsychosocial model of disability (Engel, 1977). This model suggests that how an individual experiences disability is an interaction between biological aspects (such as a cognitive impairment), psychological aspects (such as a person's values and beliefs), and social aspects (such as opportunities and accessibility). McKenzie (2013) suggested that when conceptualising disability from this perspective, disability becomes another dimension of diversity to be supported within the community.

Numeracy and Supporting Adults with ID

Historically, research into numeracy education for learners with ID has shown an over emphasis on mathematical concepts of money and time and a focus on the knowledge components of numbers and operations (Carpentieri, Litster, & Frumkin, 2010). Carpentieri et al. suggested that adults with low numeracy skills had a higher incidence of poor economic outcomes, poorer health and were less likely to be socially engaged. The United Nations (2006) convention on the rights of persons with disabilities states that individuals with disabilities have the right to access education throughout their life (article 24, p. 16). Post school education for this population is still limited. One aspect of this study is to investigate ways of improving support structures for numeracy learning for this population.

Method

Explorations of different ways in which adults with ID use numeracy in their daily activities served as a basis for designing and researching the supports for further numeracy learning in this study. We adopted a case study approach in which four everyday contexts in which adults with ID used numeracy served as investigated cases. This paper reports on the data collected in a work context of a restaurant with one participant, David.

In Phase 1 of the study, consistent with the preparation phase of design research (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003), the first author used 5 – 8 one-hour long audio recorded participant observations (Merriam, 2009) to document current numerate behaviour of each participating adult with ID in selected contexts. She also used these observations to select learning goals for each participant. In Phase 2, she designed and trialled tools and means of supporting participants' numeracy development within these contexts acting as an active participant (support person). The remaining authors contributed to debriefing of the Phase 2 experiment sessions and conducting ongoing and retrospective analyses of the data.

To support and validate observation data, audio recorded interviews were conducted with participants and significant others such as parents and support workers. In addition, fieldnotes and copies of participant's work were collected from each observation.

Data Analysis

Transcribed conversations and observation field notes were combined and initially coded using the descriptive categories from the numeracy model. Systematic reading of observation data logs provided an overview of participants' numerate behaviour. Once these facets of numeracy had been coded, they were then analysed using the disability model where the impacts of the dimensions of disability within facets of numeracy were also coded.

Interviews were transcribed and coded similarly and were used to support, verify or expand on observational data. Phase 1 analysis provided information on the current numerate behaviour of participants. Ongoing analysis of Phase 2 data provided feedback for refinement of designed means of support, while retrospective analysis of Phase 2 addressed questions about the effectiveness of designed tools and supports to enhance participants' numerate behaviour. The analysis reported here draws on Phase 1 data and demonstrates the importance of this analysis in the design of viable goals for Phase 2 of the study.

Results

Ellis (2012) suggested that adults benefit from further learning if that learning is relevant, and necessary to the adult within the context of the activity they are completing. Hence, the analysis of numerate behaviour in Phase 1 provided starting points for not only individual design, in that it documented the participant's current abilities and skills; but also, their interest and willingness to learn. This analysis thus served as a basis to establish areas of possible further numeracy development that were both appropriate (for mathematical knowledge), and important to each participant, with respect to their starting point. On this basis, we then developed specific learning goals aligned with the participants' interests.

Once an appropriate mathematics goal for learning was chosen and justified as important to the participant, support required to progress towards that goal was developed. We relied on two conceptual resources to develop these goals and the means to support participants to achieve them, the numeracy model (Goos, 2007) and the biopsyhcosocial model (Engel, 1977). While the former oriented our understanding of numeracy and how it can be supported, the latter prompted us to consider the biological, psychological and social aspects of disability that impact on adults with ID in learning.

Cobb (2000) emphasized the importance of tools in supporting the learning of students in mathematics, suggesting that designing tools should be integral to the design of activities in mathematics. For adults with ID, the use of tools (such as calculators, models, and measuring tools) has been shown to be effective in improving learning outcomes for individuals with ID, both at school, and post school (Prendergast, Spassiani, & Roche, 2017).

The design of learning activities was equally important to the success of these adult learners in working towards their goals. Disability education research suggests that learning needs to be contextual, use concrete supports and tools; consider and respect the previously learnt knowledge of adults; and be individualized to the strengths and of individuals (Diez-Palomar, Menendez, & Civil, 2011). We now outline the individual design cycle.

The Individual Design Cycle

The design research cycle consisted of iterations of design, experiment and analysis (cf. Gravemeijer and Cobb, 2006). Observation of participants' current numerate behaviour during Phase 1 was crucial in establishing starting points for participants' further numeracy learning and setting the learning goals (see Figure 2). With these goals in mind, we then designed tools and tasks to support participants. Figure 3 shows that the tools and tasks were transformed through iterations of designing, experimenting and analysis before they adequately supported participants in progressing towards their goals. For example, in the design phase, tools and tasks were designed that were conjectured to be both appropriate and achievable for the learner. These were then tested for both appropriateness with respect to participant's current interests and needs and effectiveness as a means of supporting the envisioned learning during the experiment phase. During the ongoing analysis phase, data from the experiment phase were considered with regards to facets of numeracy and disability

that became apparent in this context. The analysis insights were then factored into the refined design for the next iteration.

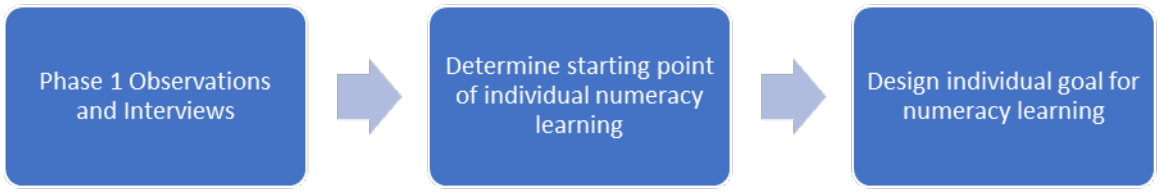

Figure 2. Initial design process.

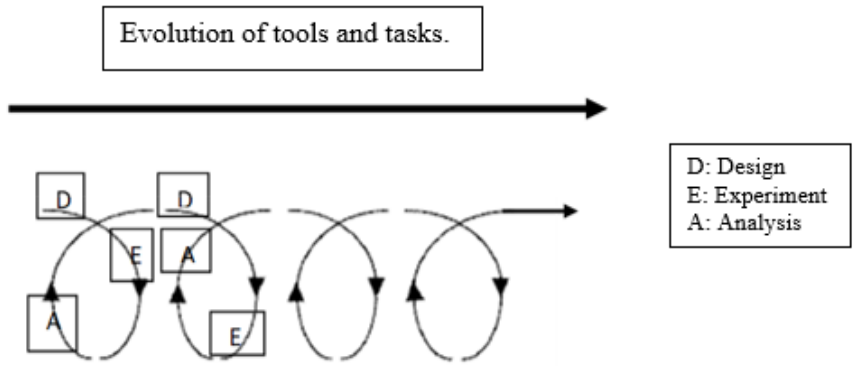

Figure 3. Cyclic nature of design research.

Table 1
Determining and Justifying Individualised Goals

Context	Observed capabilities and difficulties	Goal	Justification
The Restaurant: David	**Capability**: Read digital and analogue time Convert between digital and analogue time Round time to nearest five minutes **Difficulty**: Determine duration of activities during the shift	Develop a sense of time as duration beyond time as a label for a specific moment Be able to respond to questions regarding the duration of events	David is the only worker who can read the time off a clock David is proud of his ability to tell the time and is keen to help Lisa Enhance David's ability to help Lisa in decisions

Goal Development and Justification.

Establishing viable goals for participants' numeracy development required the understanding of current numerate behaviour and interests. The importance of establishing individualised numeracy goals for adults with ID is supported by Folk, Yamamoto and Stodden (2012) who state that learning needs to consider individual strengths and difficulties. Table 1 above, provides a summary of observed mathematical knowledge from Phase 1 for David. His goals are informed by both mathematics learning progressions (Cobb, 2000) and his needs and aspirations. We now explore the importance of understanding starting points and directions in the development of individual goals in the case of David.

Designing a Goal for David

Coben, FitzSimons and O'Donoghue (2000) argued that numeracy for adults "has the potential for empowerment, even emancipation" (p. 5). This potential was the key to establishing the importance of further development of numeracy for David who demonstrated leadership qualities and an interest in helping Lisa (support worker). Amongst his roles at the restaurant, David collected the boxes of chips from the store room and kept track of the number of boxes sorted into the trays. He often assisted another worker who used a measuring container to measure the chips into the trays. The worker would sometimes only partially fill the measuring container, tip it into the chip tray and then add a few more chips in an ad hoc manner.

The worker filled measuring container incompletely and added the chips to the tray.
David: That [measuring container] isn't full. You need to fill it all the way to the top.
Lisa: [Came over to check on progress and watch the worker fill the container right to the top.] That's it, you've got it.
David: Well done mate.
Lisa: That's great David, you guys work so well together.
(Phase 1 restaurant, observation 7)

This conversation was indicative of David's support for his fellow workers. During Phase 1, David was observed supporting others on 11 occasions. Lisa routinely encouraged supportive environment. However, the workers were not given the opportunity to participate in many decisions that were required in the work environment, such as decisions about the progress of the shift. For example:

Lisa: What time is it buddy?
David: [checking his watch] 12:07
Lisa: How many [garlic bread] are left?
There were 3 boxes left as well as the box the clients were working on.
Lisa: I had better do one of these. [Lisa completed a box of garlic bread to ensure they finished on time.]
(Phase 1 restaurant, observation 3)

In the above conversation, Lisa made decisions about how much time was left of the shift and, if the workers would have time to complete the remaining tasks. She decided that they were unlikely to finish. Whilst she involved David in this decision by asking him the time, it was Lisa who made the decision. The comments 'how many are left' and 'I had better do one of these' were not directed at the workers and hence they were not involved in this decision. Lisa provided further information during her interview.

Lisa: David can tell the time and I like to encourage him to as well you know. Often it is helpful as I don't wear a watch and there is no clock in the area where we work. … He [David] is the only one who can tell the time and it makes him feel useful, you know, important like, so that is good for his self-esteem.
The researcher, first author, asked Lisa if she thought that David might be able to make decisions similar to the scenario above.
Lisa: Well he can tell the time, but I am not sure that he could do that [make decisions on the progress of the shift] on his own.
Researcher: Have you tried to support David in helping you make these decisions?
Lisa: Not really. I don't really know how to do that, and it takes up time too, you know. They have a job to do and that is the main priority, to get the work done.
(Phase 1 interview with Lisa)

Additional Phase 1 observations demonstrated that Lisa's concerns were valid. While David could consistently tell the time at any given point, he did not understand time as duration. For instance, David would judge that the length of his shift, which he knew started at 11 and finished at 12:30 was "like an hour or something, it isn't too long" and reported

that he did "a 50-minute workout, I mean a 30-minute workout from 4 O'clock till 5 O'clock only." In these and other judgements, he relied on his sense of duration, and did not view the numbers that represented time in the moment as relevant to establishing duration.

With David's demonstrated willingness and ability to support and help Lisa and his fellow workers, and his strength and interest in telling the time, we concluded that there was potential for David to play a more active role in these types of workplace decisions. To do so, he needed to build on his existing numeracy skills and come to understand time as duration in ways that would enable him to respond to questions involving this concept. This was thus selected as the immediate goal for David's further numeracy learning.

Discussion

This research demonstrates the process of the development of numeracy learning goals for adults with ID and asserts the importance of selecting suitable goals to learning success. In design research in mathematics education, overarching learning goals are shaped by classroom curriculum and existing research in the learning domain. The design research cycle then focusses on the tools, activities and other means that would support students' progress from their current understandings towards that goal, usually in classroom settings. In contrast, when using design research to support the individual numeracy learning of adults with ID, the design of an appropriate, viable, and (relatively speaking) short-term goal became an important focus. Each learner's initial understandings and skills had to be explored and carefully considered in selecting their learning goal.

To ascertain the importance and value of the goal to the individual learner we chose to select the goals within settings that already carried meaning and significance for the learner, and represented an area where the learner could perceive numeracy improvement as a personal gain. In these settings, it was then important to understand how the individual learner already used numeracy skills to complete routine activities. In conjunction with an understanding of current numeracy difficulties, or skills not yet established but potentially relevant to the activities performed, this was used to establish learning goals for each individual that were likely to be both achievable with respect to their prior mathematical knowledge and skills, and valuable from the learner's perspective. Understanding of the sources of the difficulties and limitations was then leveraged to design means of support.

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