Chapter 10: Understanding and Mapping Digital Literacy for Students with Disability

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Abstract

Digital literacy capability is important for all students, particularly for those with disability, as it can enable access to learning. The challenges in understanding what this capability means for students with disability, and how their learning in this area progresses, has created difficulties for teachers in supporting these students to become digitally literate. To address this challenge, this study sought to define the construct of digital literacy for students with primarily intellectual disability, with the aim of developing an assessment of digital literacy capability. By incorporating the knowledge of those with subject matter expertise, such as experienced specialist teachers, and the assessment data from 1,413 students with disability, the study applied partial credit item response modelling (Masters, 1982) to develop a progression of digital literacy for these students. The strong evidence drawn from reliability indices, item and person fit statistics, and differential item functioning support multiple arguments for validity. The results may assist teachers to understand the digital literacy capability of students with disability and what they are likely to be ready to learn next, for the purpose of targeting teaching for learning.

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Introduction

The instincts of many teachers about the value of digital literacy learning for their students with disability are supported by evidence that the ability to use digital technology well can provide substantial benefits to their learning. For example, the use of digital technology by students with learning disabilities seemed to provide significant improvements in reading comprehension (Meyer & Bouck, 2014), especially when used within a *Universal Design for Learning* framework for instruction (Hall, Cohen, Vue, & Ganley, 2015). Associations have also been suggested between digital technology use and improvements in maths for students with moderate to severe cognitive disability (O'Malley et al., 2013), and in science comprehension for students with autism spectrum condition (Knight, 2010).

While other foundational areas of the curriculum, such as literacy or numeracy, remain of critical importance to students with disability, many students require the effective use of digital and/or assistive technology to access opportunities for learning in these areas (Israel, Marino, Delisio, & Serianni, 2014). Such opportunities for learning can include those requiring social interaction, information presented in inaccessible formats, and/or activities which involve physical movement (United Nations Educational Scientific and Cultural Organisation [UNESCO], 2006), all of which may be difficult if not impossible for students with disability to access on the same basis as their peers without disability (Department of Education Employment and Workplace Relations, 2012) without the use of technology. There is strong agreement worldwide that digital literacy is an important 21st century skill for all students, regardless of disability, due to the widespread and growing digitisation of the sociocultural world, and the need for students to be able to navigate this world effectively (Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014; Organisation for Economic Co-operation and Development [OECD], 2015; G. K. White, 2013). The teaching and learning of digital literacy to enable students to use digital technology for the purpose of accessing learning can thus be seen as a cornerstone of their education in the 21st century.

This research sought to assist teachers in their ability to identify a student's point of readiness to learn digital literacy capability, using the same developmental assessment approach described by Griffin (2014) to develop an assessment tool for all teachers of students with disability to allow them to identify the point of student readiness to learn digital literacy, plan targeted instruction, and evaluate the success of their interventions. Data collected from the draft version of the tool was used to create a learning progression, which described the typical digital literacy learning pathway for students whose primary disability was intellectual, so that teachers could make evidence-based planning and teaching decisions, including setting learning goals for what a student would be likely ready to learn next (E. H. White, 2019).

Developing and Mapping the Construct

Initial workshops to discuss the construct and capabilities of digital literacy for students with disability were held with subject matter experts in specialist education, ICT education and/or assistive technology education, including experienced teachers of students with disability from specialist and mainstream schools and resource centres, people with lived experience of disability, academics, and representatives of stakeholder groups. Although the workshop participants held strong ideas about the importance of digital literacy learning for students with disability, consensus suggested that neither the construct nor the competencies within it could be sufficiently defined for the purposes of developing and validating a measure of digital literacy. Indeed, the questions of determining whether the measure would assess a student's general ability to use digital technology, or the ability to use digital technology to assist with learning, or some permutation of the two, and what the relationship might be with the use of assistive technology required by many students (e.g., Fajardo-Flores, Michel-García, & Pulido, 2008; Farmsworth Jr & Luckner, 2008; Hitchcock& Stahl, 2003; Kelly, 2009, formed much of the workshop discussions. This was likely due to the novelty of the construct as well as the myriad challenges in understanding and teaching digital literacy (Aviram & Eshet-Alkalai, 2006; Ehrlich, 2013; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurer, & Sendurer, 2012; Janssen et al., 2013; Prestridge, 2013; Tour, 2015). These initial dialogues flagged the complexity of the task of defining the construct from an early stage, indicating that substantial theoretical work was needed before any further progress in developing a draft assessment could be attempted. This led to an investigation of scholarly discourse and research, including peer-reviewed journals and edited books on the education of students with disability, philosophies of technology, interpretations of literacy, and conceptual approaches to digital literacy (and its many cognates), for evidence of what digital literacy could mean and how its learning could be understood for students whose primary disability was intellectual. The discoveries from this process would then serve as a foundation for the drafting of the construct definition, indicative behaviours, and many of the quality criteria. The definition of the construct of digital literacy is a necessary component of drafting a framework for its assessment. To draft such a framework, the philosophical and conceptual moorings of the construct model created for digital literacy are presented.

Living in the digitised world

The infiltration of digital technology into nearly every aspect of daily life in has forced a fundamental shift in the ways in which we work, access and create information, and connect with one another. While the wider world navigates the impact of these constant developments, Martin (2006) predicted that the personal response can be no less complex: "out of all the challenges offered by a digitally infused society, the question of how individuals can understand, and cope with, the digital world becomes a significant one" (p. 7). Literacy with the medium of technology is now a requirement in order to participate in the sociocultural activities of modern day culture (Ala-Mutka, Punie, & Redecker, 2011; Alper & Goggin, 2017; Innovation & Business Skills Australia, 2013; Iordache, Baelden, & Mariën, 2016; National Council on Disability, 2011). Participation in the sociocultural practices of the postmodern world, including learning, requires not only the capacity to use digital technology to do so, but also the capacity to understand and maintain control over our relationships with technology.

Digital technology as tool or instrument

To understand the nature of digital technology use also requires some reflection about the nature of digital technology itself, such as whether it might be contemplated as a type of tool or instrument for enabling action. The metaphorical equation of technology and, in particular, digital technology with a tool, cultural or otherwise, can be one of the most familiar ways to consider them in everyday life, as an indication of the nature of their utility and availability (Stevenson, 2008). This is especially true with reference to the range of theoretical conceptualisations of tools and tool usage (Heidegger, 1962; Vygotsky, 1978; Wittgenstein, 1953). While Davis et al. (1997) noted a more simplistic approach to this metaphor to understanding digital technology as analogous to physical tools, Stevenson (2008) suggested that the metaphorical aspects of technology become apparent in the amalgamation of the physical and the virtual within a digital application. Referencing Heidegger's conditions on "readiness-to-hand" (1962, p. 135), Stevenson's (2008)analysis of the power of the tool metaphor of digital technology highlighted the practical, purposeful nature of digital technology due to its ability to achieve the meeting of an end and, in doing so, its dual transparency and opacity to users. That it is transparent can mean that the tool is 'good' (Heidegger, 1977); in that it can achieve its end without a focus upon itself, and similarly, its opacity can mean the same, for the user does not need to know how it does so.

It is important to understand, however, that Heidegger's (1977) later and ontological analysis of technology did not actually concern technology as it is more commonly understood to be. Harman (2010) offered that Heidegger's tool analysis and views on technology were not confined to specific entities as could be readily misinterpreted; technology was not necessarily a high-tech device nor was a tool necessarily a hammer. Rather, it was in Heidegger's ontology of things that the true nature of technology and tools was to be found, instead of in his comparatively thin discussions of technology as such.

In addition to an understanding of digital technology as a tool, digital technology may also be considered within Verillon and Rabardel's (1995) notion of an instrument as a psychological construct. Their positioning of digital technology as an instrument drew attention to differences between the physical object and its incorporation into the actions of the user towards an end (Verillon & Rabardel, 1995). Vygotsky's (1978) differentiation between technical and psychological tools, and how they can be used to comprehend and manipulate the material and cognitive domains, demonstrated parallels with Verillon and Rabardel's (1995) concept of the instrument in comparison with the artefact, that the instrument becomes an instrument by the nature of its ability to be appropriated and subordinated to achieve the ends of the user.

Heidegger's earlier and more negative responses to technology were acknowledged by H. L. Dreyfus and Spinosa (2003), such as those mentioned by Harman (2010) and Blitz (2014), before Heidegger (1977) made the critical statement that "we can affirm the unavoidable use of technical devices, and also deny them the right to dominate us, and so to warp, confuse, and lay waste our nature" (p. 54). This recognition of the recent, yet deep integration of digital technology into everyday life serves as a reminder of the importance of our understanding of our relationship with it, and how it affects our very being as humans. We must become constantly mindful of our relationship with, and understanding of, technology's role in everyday life in order to combat technology's potential position as a dictator and efficiency-maker of our experiences of the world (Blitz, 2014).

It is its enmeshing into human culture and society that provides the best argument for the critical understanding of technology and the intelligent, considered use of it. If all human beings are to remain able to understand and participate in the social and cultural contexts in which they live, which now include the digital world, then that understanding and participation hinges on the development of an adequate literacy of those contexts. Such a literacy must include an awareness of the role and relationships that technology has with the individual, with the interpersonal relationships of the individual, and with society and culture as a whole. This recognises the ubiquitous, impactful nature of the technology of the postmodern world, forcing the need for a new path towards understanding life in the postmodern age (Walters & Kop, 2009), such that digital literacy then becomes a means with which to make sense of the socio-cultural-technological-digital modern world.

Literacy in a sociocultural constructivist framework

Within this postmodern world, the comprehension of, and ability to cope with, the demands of life within it (Walters & Kop, 2009) has been conceptualised by many as a type of literacy. This commonality and integration into the routines and practices of living in the sociocultural world then positions the notion of literacy as being inseparable from the context in which it occurs. Within such socioculturally-situated practices and understandings exist the central actions of making and conveying meaning using a symbol system (Scribner & Cole, 1981; Woods, 2010) as well as cultural tools, texts, and ways of thinking in the construction of reality (Bruner, 1996). As identified by Scribner and Cole (1981), however, literacy is more than simply the effective use of a symbol system and tools; rather, it is the application of this knowledge for specific purposes within particular contexts.

Being literate can thus be defined not only as being able to read and write the symbols but also as the ability to do so in a culturally appropriate manner. The positioning of literacy as a situated social practice (Peréz, 2004), rather than a discrete set of decontextualised skills, is analogous to certain conceptual approaches to the understanding of digital literacy, including the one developed for this study. The sheer diversity of approaches to digital literacy, its cognates, and related terms, however, requires an exploration of the main conceptualisations to better situate the construct as developed and applied for this study.

Conceptual approaches to digital literacy

An interrogation of the many and varied conceptualisations of digital literacy, since the generally-accepted advent of the term in English language research literature (Gilster, 1997), yields roughly three main approaches. Even within these approaches, wide variation exists, including the discussion as to whether the term should be singular (digital literacy) or plural (digital literacies) (Lankshear & Knobel, 2015) in recognition of the range of skills, competences, or literacies required to be digitally literate. In addition, while the term digital literacy has been chosen for this research, related terms such as:

- digital competence (e.g., Calvani, Fini, & Ranieri, 2009; Ferrari, 2013; Ilomäki, Paavola, Lakkala, & Kantosalo, 2016; Søby, 2015);
- technological competence (Selwyn & Husen, 2010);
- ICT competency (e.g., UNESCO, 2011);
- ICT competence/s (e.g., Aesaert, van Braak, van Nijlen, & Vanderlinde, 2015; Aesaert, van Nijlen, Vanderlinde, & van Braak, 2014);
- ICT literacy (e.g., Mahmud & Ismail, 2010);
- digital information and communication skills (Siddiq, Scherer, & Tondeur, 2016); and
- digital Bildung (Søby, 2003)

are sometimes considered to have equivalency with digital literacy (in itself having many definitions), and with each other. In many cases, considerably different constructs and frameworks exist between different terms and within the same term when applied by different scholars or organisations (see Cartelli (2010), Ferrari (2012, 2013) and Janssen et al. (2013) for a comparison of some of these). Such complexity in the terminology presents a particularly strong need to adequately position the construct of digital literacy as defined and applied in this research.

The first approach to digital literacy focused largely on the concept of literacy as it is traditionally understood, but situated literacy within a networked, technological space, mainly in response to the increasingly rapid digitisation of information and utilisation of technology. Martin identified several "literacies of the digital" (2008, p. 156), including computer literacy; information technology, or ICT literacy; technological literacy; information literacy; media literacy; visual literacy;

communication literacy; and lastly digital literacy. According to Cihak, Wright, Smith, McMahon, and Kraiss (2015), the many challenges faced by teachers in the digital age included reshaping their own understandings of what literacy means. Literacy needed to expand past older notions of reading and writing to include the comprehension of information offered in digitised formats. Selfe (1999) and Selber (2004) also took a literacy-centric view of digital literacy. Selber (2004) discussed the multiliteracies approach, with its three literacy categories – functional, critical, and rhetorical – and noted that students who do not receive sufficient exposure to each category are likely to face challenges in being able to meaningfully engage in activities involving technology. Twenty years ago, Selfe also acknowledged the critical and changing role of teachers in supporting the development of technological capacity in students: "literacy alone is no longer our business. Literacy and technology are. Or so they must become" (1999, p. 3).

The second approach to digital literacy moved beyond a traditional literacy-based foundation to incorporate a wider range of literacies. Coiro, Knobel, Lankshear, and Leu (2008) unpacked the concepts, theories, and research in new literacies, recognising "a number of variations of different kinds…. such as 21st century literacies, Internet literacies, digital literacies, new media literacies, multiliteracies, information literacy, ICT literacies, computer literacy, and so forth… falling broadly under a new literacies umbrella" (p. 10), noting that, while some variations were terminological, others were considerably more conceptual and theoretical.

The third main approach viewed digital literacy as a specific set of abilities with technology and digital networks, which may or may not be coupled with cognitive skills and abilities such as critical thinking, problem-solving skills, and information management. These conceptualisations of digital literacy/digital literacies offered finite, mastery-based approaches, sometimes known as the autonomous model or as "standardised operationalisations" (Lankshear & Knobel, 2015, p. 9) of digital literacy, with roots in the concept criticised by Gilster as the "keystrokes" (1997, p. 1) approach of mastering a list of set skills or operations or Gilster's "concern with meaning" (as discussed byLankshear & Knobel, 2015, p. 10).

Lankshear and Knoebel described three key features of such "mainstream accounts of digital literacy" (2015, p. 10). First was the confinement of digital literacy to roles concerned with information and, secondly, the conflation of interaction with information with epistemic engagement with information. The last feature was the construction of digital literacy as

> an 'It' – as some kind of a 'thing': a capacity of ability, a skill (or set of skills), or 'master competency' (composed of more specific competencies and dispositions). It is something you 'have', or lack, and anyone who lacks it 'needs' to get it. Accounts differ about what is actually 'in' this thing…. The assumption is that when people have this 'thing' they can handle information

> effectively and use it to consume and produce information in all kinds of settings and roles – as private citizens, workers, parents, teachers, learners (2015, p. 11).

Confining digital literacy to purely or predominantly informational matters, however, negates the role of social practices within a digital, networked space (Schreuer, 2014). In addition, relationships between technology and the individual, technology and the nature of a task, and technology and society and culture must be positioned for scrutiny within the development of a literacy with digital technology and its use. To neglect the consideration of the nature and role of technology, and its impact upon the personal, social, and societal, is to prevent the development of a full understanding of, and therefore control over, the very tool one seeks to master.

Lastly, the attempt to conceptualise digital literacy as a finite or autonomous entity attracts the same argument as the attempt to conceptualise conventional literacy as a finite or autonomous entity; that, in a sociocultural constructivist framework, any set of skills or techniques is shaped by the social practices it inhabits, where different purposes or meaning-making may exist. In keeping with the consideration of digital and networked technology as a cultural tool, Eshet-Alkalai (2004), and together with Aviram (2006), discussed and supported the necessary evolution of the concept of digital literacy to move past previous, conventional notions of required skillsets and cognitive abilities.

Definition of the construct of digital literacy

As a situated social practice, digital literacy is here defined as *being able to interpret and use the symbols, text/ graphics, and tools of digital technology and networks, and also the ability to do so in a culturally appropriate manner.*

For students with disability and/or additional needs, as for students who do not have a disability and/or additional needs, digital literacy, combined with any required assistive technology, offers an increased ability to access, create, share, and organise social, information, communication, and education opportunities, while participating in the digital, networked environment that has fast become a sociocultural norm in the 21st century. Digital literacy is not an autonomous cognitive practice, nor simply a finite list of digital technology skills to gain. It is an interactive process where communication and collaboration with others plays a significant role in defining and negotiating meaning as interpreters and users transact with symbols, text/ graphics, and digital tools in networked, digital sociocultural environments (Peréz, 2004; Street, 1995). It allows for the creation and dissemination of new knowledge and solutions from the interface of networked human beings with digital technology tools.

Digital literacy also requires a considered engagement with the tools and practices of digital technology use within the sociocultural environment, such that the impact of the use of those technologies can be understood, monitored, and, at an individual level, controlled. By engaging with digital technology in socioculturally appropriate ways, to paraphrase Heidegger (1977), we can affirm their integration into the 21st century world, and also their usefulness to us, but also deny them the ability to control us and how we engage with the world. While students with disability may require the use of technology to engage with the world on an equal level with their peers without disability, the point of difference is the enablement of these students to understand, and thereby make decisions about their use of, technology. Without such enablement, it is possible that the technology may, even subtly, control their interactions, rather than the students. In effect, this would then remove the very autonomy that technology use might promise, so it is critical that, at all times, it is the student who interacts with the world, on his or her terms, though a mindful application of technology to his or her desired ends.

The development of digital literacy is here considered an interactive process in which the learner engages with not only digital technology tools and networks, but also with other human beings through that technology, as he or she negotiates an understanding of the digitised world and the relationships within it, for the purpose of learning. The two strands identified – learning to use digital technology and using digital technology to learn – served to frame the indicative behaviours and the development of items, and acknowledge the conscious, purposeful, and intertwined nature of the construct.

Developing the SWANs Digital Literacy Assessment

Following the definition of the construct, the next step was to identify a taxonomy capable of providing an underlying structure to map how digital literacy capability could unfold in terms of increasing ability. Designed to elicit the proficiency of students with disability in the general capability of digital literacy, this evidence framework was devised with support from the knowledge of experienced teachers of students with disability, and underpinned by the review of scholarly discourse.

Applying S. E. Dreyfus and Dreyfus' (1980) taxonomy

An adaptation of S. E. Dreyfus and Dreyfus' (1980) five-stage model of directed skill acquisition offered an effective explication of the transformations expected to occur along each stage of learning within the construct. S. E. Dreyfus and Dreyfus' (1980) taxonomy was chosen due to its focus on skills, as digital literacy could be considered as largely a skill-based phenomenon. This is due to its basis in learning to apply tools and instruments for a purpose (i.e., first, how the tool or instrument *worked*, and secondly, in order to use it to learn). Their taxonomy featured five developmental stages through which a learner would be expected to progress in acquiring a skill by means of instruction and engagement in concrete experiences. These stages were categorised as *novice*, *competence*, *proficiency*, *expertise,* and *mastery*. The process of becoming increasingly skilled was based on the notion that the learner moves from a dependency on de-contextualised rules as provided by an instructor about how to determine an action or response to a situation, to a reliance on his or her own perceptions of a situation, based on learnings from previous engagement in concrete experiences, to guide his or her actions. The five stages of their model provided a clear scaffold from which to conceptualise the pathway of learning within digital literacy capability, and allowed for expansion into additional lower levels to accommodate learners at nascent stages of ability. For students with more severe degrees of intellectual disability, the nature of their impairment may be such that they are not yet able to engage in the novice stage, which requires following rules. To recognise such preliminary stages of learning, two stages were added prior to the novice stage: *attending to phenomena*, followed *engaging with phenomena*.

Drafting the indicative behaviours

A further workshop was held in which teachers with subject matter expertise reviewed the outcomes of the review of research literature and scholarly discourse. Participants consisted of twenty-one teachers from specialist schools, a speech pathologist from a specialist school, three assistive technology teachers from a vision impairment-specific education resource centre, one assistant principal from a specialist school, a curriculum leader from a specialist school, and three academic researchers in the fields of learning intervention and educational assessment. One of the assistive technology teachers identified as a person with a vision impairment. Representatives of the Victorian Government Department of Education and Training's Student Wellbeing Division, and principals of schools previously involved in the related research (Coles-Janess & Griffin, 2009; Roberts & Griffin, 2009; Woods, 2010) had identified this group as experienced and knowledgeable in their respective fields. The workshop participants unanimously endorsed the definition of digital literacy developed for this work. They were then asked to create a pool of indicative behaviours that could be used to observe and monitor the development of digital literacy proficiency in students with disability. Items were drafted in the form of observable, teachable, and relevant *indicative behaviours* within the two identified strands of digital literacy.

Within the first strand of digital literacy, *Learning to use digital technology*, it was determined that to learn to use digital technology, behaviours that support attentiveness to, and interest in, the digital technology tool or skill to be learnt were required. The initial indicator *Paying attention to digital technology* was split into two indicators, *Paying attention to familiar digital technology* and *Paying attention to unfamiliar digital technology*, as a result of the workshop participants' feedback. The workshop participants argued that this degree of specificity was important, as they contended that the ability of many students to demonstrate the attention to digital technology could be dependent on whether the technology was familiar to them or not.

As digital technology is both a tool and an instrument (Heidegger, 1977; Stevenson, 2008), the ability to request to use it, and to make choices about its use, were determined to be behaviours needed to facilitate access to it and support critical thinking about its use in a culturally appropriate manner. The behaviour of exploring digital technology to determine what its functions and applications may be supported the construct definition's statement of being able to *interpret and use the tools* of digital technology. Being able to control one's use of digital technology, such as by stopping the use of it when necessary, was an inherent aspect of socioculturally appropriate use. Socioculturally appropriate use was also considered to include the care of digital technology, as well as its safe use. As the use of digital technology requires it to be working, the behaviour of managing problems with digital technology was included to support the capacity to address issues with the purpose of facilitating access to the digital technology. The behaviours of using digital technology symbols and applying digital technology terms were echoed within the digital literacy construct definition of *being able to interpret and use the language and symbols of digital technology*. These behaviours were included to underpin the ability to understand the graphical content displayed on a screen, such as icons, which do not require the use of higher-level literacy skills that may not yet be present in many students with disability. Being able to make sense of these symbols, and to use them, facilitates access to digital technology devices and programs/apps via meaningful interaction with these symbols. Similarly, the ability to interpret and use the language of digital technology, such as the terms for objects (e.g., *tablet, port*) or actions (e.g., *pause, save*) supported the capacity to communicate about digital technology use and to develop understandings about how digital technology work and how they can be used for the purpose of learning.

Within the second strand, *Using digital technology to learn*, the behaviour of being able to respond to the information or content presented via the technology was included to address the ability to use that information or content for the purpose of learning. The behaviour of using digital technology to create information and content was included to support the harnessing of digital technology as a tool or instrument for learning, as do the behaviours of finding, storing, and sharing information and content using digital technology. These behaviours were determined to facilitate learning through the creation, access, and manipulation of information and content through the tools of digital technology. The behaviour of making a choice about information and content was included to support the ability of a student to use thinking skills and determine which information or content he or she might prefer, or that might be more useful or appropriate for a learning task.

Table 1 Draft of the Indicative Behaviours of Digital Literacy Capability Post-Workshop

	Behavioural indicator
Strand: Learning to use digital technology	1. Paying attention to familiar digital technology 2. Paying attention to new or unfamiliar digital technology 3. Showing interest in digital technology 4. Requesting to use digital technology 5. Making choices about the use of digital technology 6. Controlling own use of digital technology 7. Exploring digital technology 8. Managing problems with digital technology 9. Caring for digital technology devices and peripherals 10. Using digital technology symbols 11. Applying digital technology terms 12. Using digital technology safely
Strand: Using digital technology to learn	13. Responding to information/content presented via digital technology
	14. Creating content using digital technology
	15. Finding information/content using digital technology
	16. Storing content using digital technology
	17. Sharing content using digital technology

Drafting the quality criteria

To determine the initial relative difficulty of the quality criteria within each indicative behaviour, the participants reviewed the developed quality criteria for alignment with the modified version of S. E. Dreyfus and Dreyfus' (1980) taxonomy. They were also asked to make suggestions for additions to the draft criteria for the purpose of improving the capacity of each item to describe an increase in ability of the underlying trait targeted by the item. They were then asked to order the quality criteria from least to most difficult to confirm that the ordering was correct and to identify substantial gaps between the quality criteria. In instances in which quality criteria had not yet been developed for a behavioural indicator, or a sufficient number of criteria had not yet been developed, the participants were asked to draft them. This full set of criteria were again reviewed against the adaptation of S. E. Dreyfus and Dreyfus' (1980) taxonomy. An example of the alignment between the taxonomy and the quality criteria is shown in Table 2, in which the draft versions of the quality criteria, or item-steps, of Item 6 (*Exploring digital technology*) were matched against the adaptation of S. E. Dreyfus and Dreyfus' (1980) taxonomy.

Table 2 Alignment of Quality Criteria for Item 6 (Exploring Digital Technology) Against the Adaptation of S. E. Dreyfus & Dreyfus' (1980) Taxonomy

Taxonomy stage	Quality criteria
Acting without conscious review of steps/ internalised experience used to guide decisions	
Acting on prior experience of success or failure to achieve personally relevant outcomes	6.4 Examines functions of digital technology by drawing on prior experience and knowledge
Following rules to achieve personally relevant outcomes (registering success or failure)	
Following rules and taking situational cues into account (contextualised)	
Following rules and steps (decontextualised, simple or single step)	6.3 Follows directions to explore functions of digital technology devices (e.g., tapping items on touchscreen, inserting earphone jack into port, pressing buttons)
Engaging with the phenomena	6.2 Interacts with physical features of digital technology (e.g., by looking at, feeling or listening)
Attending to the phenomena	6.1 Responds to stimuli in the environment (e.g., by startling, turning head, smiling, becoming still, pausing other activity)

Pairwise comparisons

The workshop participants were then asked to use their professional judgment to determine the relationship between each quality criteria across the indicative behaviours in terms of difficulty. So, for example, they needed to decide whether the most emergent descriptor of ability (the quality criteria) in the indicative behaviour of *Paying attention to familiar digital technology* was more, less, or equally difficult to the most emergent descriptor of ability in *Exploring digital technology*, and so on, for all quality criteria across the different indicative behaviours. This approach grouped the items into diagnostically meaningful levels to later assist in setting standards (Wolfe & Smith, 2007a) and created a matrix of all quality criteria within each indicative behaviour as organised by hypothesised difficulty. This *hypothesised criterion-referenced framework* (Griffin, Gillis, & Calvitto, 2004) was later used to evaluate the construct validity of the assessment instrument materials.

At the conclusion of this phase, a draft observation questionnaire was created for piloting with teachers of students with disability. The initial observation questionnaire contained 17 items as the indicative behaviours with item-steps as the quality criteria, displayed in the form of a multiple-choice survey. A sample item is shown in Figure 1, in which the item is the indicative behaviour of *Showing interest in digital technology* and the item-steps are the quality criteria, arranged in order of increasing complexity. An item-step of ‘is moving towards but has not yet achieved these skills/behaviours’ was included to recognise that some item-steps may be too challenging for some students at more emergent stages of digital literacy capability. This item-step was positioned at the end of each list of item-steps so to encourage teachers to consider the range of different degrees of ability expressed by the other item-steps before determining a student was not yet able to demonstrate even the least difficult quality criteria, as described by the first item-step in each item.

1.2 Showing interest in digital technology

- ❍ Remains present (or does not protest or shut down) when digital technology is being used by another
- ❍ Shows anticipation of a familiar and liked activity presented on digital technology (e.g., moves into position, turns towards)
- ❍ Maintains interest in digital technology when using familiar device/ program.
- ❍ Persists in using digital technology when learning to use an unfamiliar device/ program.
- ❍ Is moving towards but has not yet achieved these skills/behaviours

Fig. 1 Sample item from the hard copy version of the initial observation questionnaire used by teachers in the fourth workshop (E. H. White, 2019)

The workshop also involved the evaluation of draft questions about student and teacher demographic characteristics to investigate the suitability and fairness of the instrument for students with different disabilities.

Piloting and panelling

The draft item pool and demographics questionnaire were piloted in three schools that specialised in the education of students with disability, and reviewed by one principal, one assistant principal, and 17 teachers, including one with specific expertise in ICT education. The participants were invited to make suggestions for improvements to the content of the instrument. At the conclusion of the piloting activities, final changes were made to the initial observation questionnaire and the demographic questionnaire. The most significant change was the addition of item 18, *Communicating digitally*, which was included in the strand *Using digital technology to learn*. While there was strong agreement among the participants about its importance as an indicative behaviour of digital literacy, there was some disagreement about how commonly this behaviour could be observed in a classroom context, particularly in primary school. It was decided to include it in the trial instrument and evaluate the item closely for problems due to possible lack of opportunity to observe this behaviour.

As a final step prior to releasing the items for trial, the items and demographic questionnaire were panelled with experts with specialist knowledge in educational assessment and learning intervention. Minor edits were made to the wording of a few of the quality criteria as well as the demographic questionnaire for clarity or brevity. A statement was also included with the items that confirmed that students could be assessed for digital literacy capability with or without the use of any assistive technology.

Collecting Data on Student Digital Literacy Ability

Data collection for the trial was undertaken online via a portal hosted and maintained by the University of Melbourne. This method allowed teachers to participate at their convenience and facilitated analysis through the digital organisation of the data collected. The data were stored securely on a password-protected server at the university, and only the researcher and programmer had access to the data collected in this study, in accordance with university and the Victorian Government Department of Education and Training research ethics requirements.

Demographic backgrounds

Completed trial assessments were received from 61 schools in the Australian states of Victoria, South Australia, and Western Australia. This total was comprised of 55 specialist schools, five primary schools, and one secondary school, representing metropolitan and rural/regional areas. A range of specialist school types were represented, including schools dedicated to the education of students with mild intellectual disability, moderate to profound intellectual disability, physical disability/health impairment, autism, and who are d/Deaf or hard of hearing. After cleaning for missing or erroneous responses, data was retained from 1,413 students, provided by 565 assessors, mainly consisting of classroom teachers in specialist settings (98.6% of teachers) and a small number of other education professionals or paraprofessionals.

Students ranged from three to 21 years old, with an even distribution by age and an average age of 11.3 years old. The gender split of 69.9% males and 30.1% females was consistent with other statistics which reflect the higher incidence of disability among male children (Australian Institute of Health and Welfare, 2004). When organised into the disability sub-groups available on the demographic questionnaire, the most common disability was intellectual disability (n =1138, or 80.5 %). Most students had more than one disability, with the most common combination of disability being autism spectrum condition and intellectual disability (n =257, or 18.1%). Other disabilities represented in the study included physical disability, vision impairment, d/Deafness or being hard of hearing, severe behaviour disorder, and severe language disorder.

Psychometric analysis

Data were calibrated using item response partial credit modelling (Masters, 1982). The item-steps were interpreted using data output, including an investigation of reliability indices, item and person fit statistics, and differential item functioning to determine the quality of the measure. The item separation reliability score of 0.99 indicated that the items each measured different characteristics. The WLE person separation reliability of 0.97 indicated that the items could discriminate well between different levels of person ability. The alpha reliability of 0.97 indicated very strong overall consistency of the items. As per advice from Kubiszyn and Borich (1993), coefficients of 0.99, 0.97, and 0.97 reflect strong internal consistency. After determining the quality of the instrument, the item-steps were plotted according to increasing difficulty and further interpreted using other data outputs.

Regarding item fit, the initial analysis showed that Item 18 (*Communicating digitally)* had a fit score of 1.67, indicating a potentially unacceptable degree of misfit to the model. After consideration of the possible reasons for misfit, including lack of opportunity to observe this skill, Item 18 was removed and the data reanalysed. Of the 17 other items in the trial, only two showed some degree of misfit to the model. As a fit score close to 1.00 is desirable (Wright, Linacre, Gustafson, & Martin-Lof, 1994), Item 3 (*Showing interest in digital technology*) had a fit score of 1.46 and Item 11 had a fit score of 0.71. Upon review, the degree of misfit with these items was insufficient for revision or removal. Overall, these scores demonstrated very high item technical quality.

Person misfit was also analysed to determine whether the response patterns for students were aligned to expectations of student ability. A very low incidence of person misfit to the model was found, with 1.3% of students (n=19) having a PFIT score ≥ 3. Of these students, the data from 12 were excluded after individual review to determine plausibility of the response pattern. The low incidence of person misfit indicated that teacher and student background characteristics had a negligible impact on the teacher's ability to assess a student using this measure, and on a student's level of digital literacy learning.

Differential item functioning (DIF) was investigated to determine the impact of student background characteristics, including disability type, on their digital literacy learning. Significant DIF was not detected, meaning, for example, that a student with autism had the same pattern in their digital literacy learning progression as a student without autism, and therefore the same likelihood of success on each item.

One of the main outputs used to determine the learning progression was the variable map shown in Figure 2. The variable map orders the difficulty of the *logits* (log units, shown as whole numbers on the left of the figure) of all of the item-steps (the numbers on the right of the figure, e.g., 2.1), which served as the basis for developing the learning progression and the levels within it. In doing so, the variable map presents and locates both students and items using the same metrics. A logit is the balance between the difficulty of an item-step and, in this case, how much digital literacy ability a person needs to have a 50% chance of being able to demonstrate the skills described within the item-step. Thus, the variable map shows the number of students who had a 50% chance of being able to 'do' each of the different item-steps, with an increased likelihood of being also able to do the easier ones beneath an item-step. The spread of student ability in the trial can be seen, as well as the spread of difficulty within the item-steps. This shows the general order in which these abilities emerge in students, and a good match between the items and student abilities.

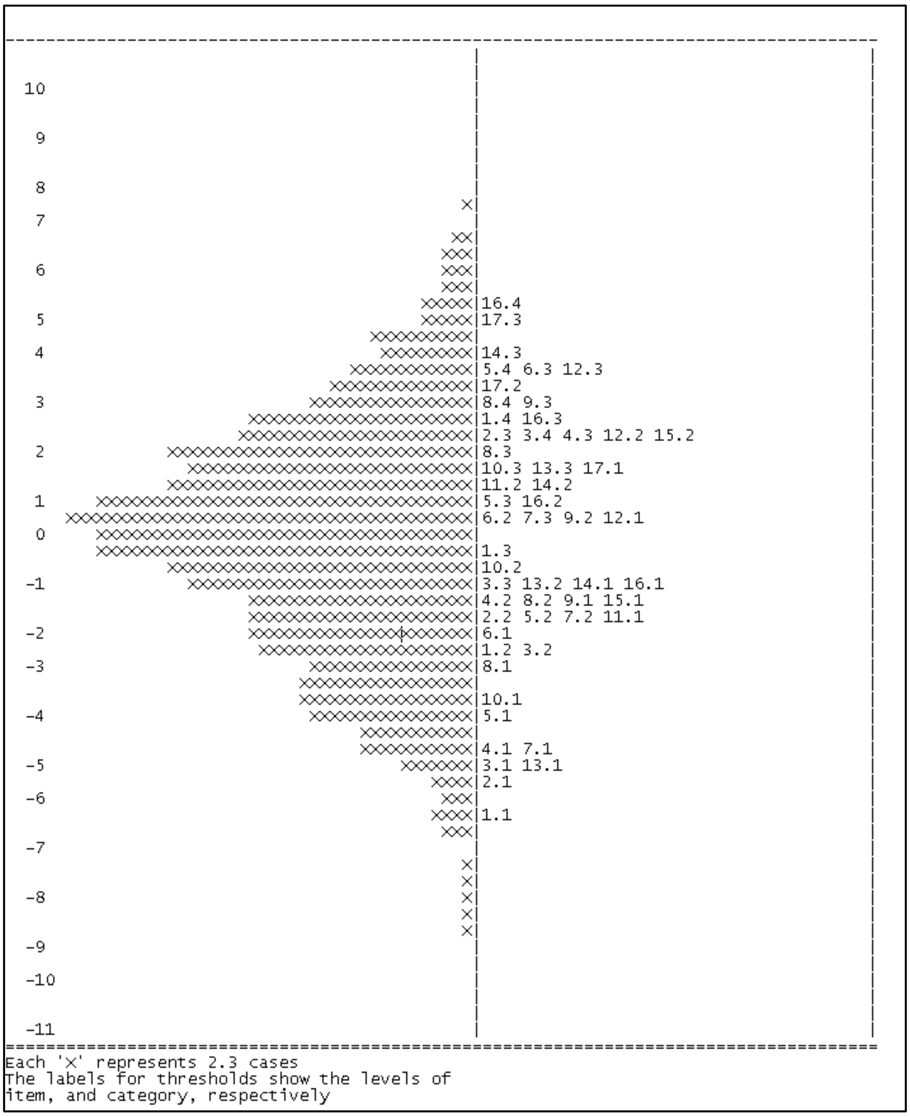

Fig. 2 Variable map, showing the difficulty of each item-step ascending from easiest to most difficult (e.g., item-step 1.3 is item 1, step 3) (as adapted from E. H. White, Woods, & Poed, 2017)

Crafting the Digital Literacy Learning Progression

The data collected on student ability was then applied to describe a pathway of expected digital literacy learning, describing how a teacher could expect a student with disability to learn to use technology, and use technology to learn, over time and with the support of an educator. Using the difficulty parameters for the item-steps as calculated during the statistical analysis, which represented the relative difficulty of each item-step in relation to the others, a continuum was created that listed each item-step from easiest to most difficult. This process also allowed for the comparison of the expected difficulty of each item-step, as determined during the creation of the hypothesised criterion-referenced framework (matrix) during the assessment development workshop, against the observed difficulty of each item-step.

Setting cut points

The item-steps were organised in order of difficulty to allow for the setting of initial levels of ability, or cut points, by others with subject matter expertise in psychometrics, educational assessment, and learning intervention. To do so, these experts looked for the sort of developmental, qualitative transition in capability as conceptualised by Vygotsky (1929/1993) as "metamorphoses" (p. 42) that can be taken as evidence of growth or development of student ability, and used to support and guide the learning that the student is ready to undertake (Griffin, 2007). The item-steps were examined for evidence of clustering, and for shifts or transitions in proficiency as marked by larger gaps between item-steps. The subject matter experts helped to determine which clusters of item-steps could be grouped so to indicate a similar level of overall difficulty. They also made decisions about whether those groupings could be interpreted as representative of the types of substantive skills and behaviours to be expected of a student working within that level.

Developing level descriptions

To summarise the type of learning which occurred within each of the identified clusters, an analysis of the content of the item-steps was undertaken, with attention paid to the broader nature of the learning exemplified within each cluster. The adaptation of S. E. Dreyfus and Dreyfus' (1980) taxonomy was also used as a framework to understand the types of learning that could be expected to occur within each cluster. The content of each level was thus reviewed against this framework to determine whether the increasing proficiencies described in each level were reflected in the transformations described in the taxonomy. As a result of the analysis of the clusters and the types of learning inherent within them, six levels of proficiency were identified. A brief *nutshell* description of each of the levels is shown in Figure 3, with each level increasing in difficulty as the numbers ascend. The full learning progression is located in Appendix X.

Level 6: Taking control of digital technology through guidelines and organisation
The student is learning to control and manage his/her own use of digital technology, including device use, file management, and sharing and editing content. S/he is starting to explain the purpose and personal importance of strategies and reasons for using different features of digital technology.
Level 5: Applying strategies and guidelines to digital technology use
The student is learning to identify strategies and guidelines to organise his/her own use of digital technology, and to look after it. S/he is starting to apply problem-solving strategies to determine the appropriate device for a task, and to resolve issues with digital technology. S/he is learning to attend to and persist in using familiar digital technology for a task.
Level 4: Using prior experience and procedures to complete tasks with digital technology
The student is learning to apply prior knowledge of familiar digital technology. S/he is starting to follow rules, group procedures, and instructions to complete tasks, create and save own content, and explore new functions and symbols. S/he may express likes and dislikes about digital technology and is beginning to use digital technology terms to describe actions or intentions.
Level 3: Engaging with digital technology and content to achieve own ends
The student is beginning to use familiar digital technology to achieve his/her own ends, by working from directions, single-step routines, or prior experience. S/he is starting to request and maintain interest in using familiar digital technology, and to identify familiar digital technology symbols.
Level 2: Making connections with digital technology through interaction with devices and programs/apps
The student is beginning to follow single-step instructions and/or relies on adult support to explore and use digital technology. S/he is starting to make a choice between two familiar digital activities. The student may recognise when something new is introduced via digital technology, or when digital technology is not working.
Level 1: Reacting and responding to digital technology and content
The student attends and/or reacts to digital technology being used by another person, and to the content on digital technology devices, such as images or sounds. S/he is starting to interact with features of digital technology with support.

Fig. 3 Brief level statements for each of the six levels of the digital literacy learning progression

Standard setting

The quality criteria (item-steps) were organised into "diagnostically useful levels" (Wolfe & Smith, 2007a, p. 235) through the identification of cut points and adherence to procedures for standard setting, including the use of experts who are adequately qualified to make the decisions required in such an activity (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2014; Wolfe & Smith, 2007a). A group of subject matter experts attended a standard setting workshop, consisting of eight expert specialist teachers in assessment and ICT/digital technology education, an assistant principal from a specialist school, an academic specialising in learning intervention, an academic specialising in psychometrics, a representative from the Student Wellbeing Division of the key stakeholder, the Victorian Government Department of Education and Training, and a PhD candidate studying the assessment and development of thinking skills in students with disability participated in a workshop to review decisions about cut points and level descriptions.

The participants reviewed the draft level statements and the condensed versions of the statements (described here as nutshell statements) to determine areas for improvement to support teacher ability to use the level statements to understand and plan for student learning. The participants considered whether the levels adequately captured the skills described in each set of item-steps and were interpretable for a non-expert teacher in ICT/ digital technology, as well as a teacher who may be inexperienced in teaching students with disability. They also reviewed the nutshell statements for adequate reflection of the main concepts in the level statements. Minor changes were made to one of the nutshell statements, with the subject matter experts otherwise endorsing each of the other nutshell and level statements.

Extent of the match- hypothesised and derived progressions

To investigate for further evidence of the construct or substantive validity of the instrument (Wolfe & Smith, 2007b; Wright & Stone, 1999), the expected order of the difficulty of each of the quality criteria (item difficulty), as described by the hypothesised criterion-referenced framework developed in the teacher workshop, was compared against the observed order of difficulty. A close match was found between the expected order of difficulty of the items and the observed order. Statistical analysis of the congruence between the teacher predictions of the order of difficulty and the observed order of difficulty showed a strong positive relationship ($\rho = .87, p < .000$). When considered against the underlying taxonomy and the derived levels, the degree of the match between the expected and observed order of difficulty was considered close enough to support an additional argument for the construct or substantive validity of the instrument, particularly when viewed in conjunction with the high indices for person and item separation reliability, at .97 and .99 respectively.

Chapter Summary

In this chapter, the definition and modelling of the construct of digital literacy was described, as underpinned by a philosophical and sociocultural constructivist framework. The approach to assessment development was then presented, using an adaptation of S. E. Dreyfus and Dreyfus' (1980) taxonomy to scaffold the mapping of the construct. The method for drafting items followed, in which teachers with specific expertise informed the development of the indicative behaviours of digital literacy ability (items) as well as criteria which could describe increasing proficiency within those indicators (item-steps) to create an hypothesised criterion-referenced framework. Piloting and panelling activities were described, in which representative teachers provided feedback on the draft items and demographic questionnaire, so to continue building arguments for the validity of the instrument.

Demographic information about the participating schools, teachers, and students demonstrated the representative nature of the trial data collected. The results of the trial were then compared via the application of the partial credit model (Masters, 1982), exhibiting strong evidence of fit to the model, and described finely grained increases in the range of digital literacy capability along a continuum. Reliability outputs indicated strong overall consistency of the items, that the items each measured different characteristics, and that the items were able to discriminate between different levels of abilities in students. Additionally, the results of differential item analyses established that the presence of a specific disability did not impact the way in which digital literacy capability unfolds (i.e., the pathway of digital literacy learning), with one minor exception that was not considered significant enough to remove the item.

To investigate additional sources of evidence for arguments of validity, the final section presented the empirical validation and interpretation activities, including the determination of cut points and level descriptions for the derived levels of ability. The strong congruence between the expected order of item difficulties and the observed order was illustrated through the mapping of the items to the derived levels and the underlying adaptation of S. E. Dreyfus and Dreyfus' (1980) taxonomy. As a collection of individual arguments, the results of the trial, including the calibration and interpretation of the data, can be seen as strong evidence for multiple types of validity of the instrument to measure digital literacy capability in students with disability, and to map the growth of this capability as students increase in their capacity to learn to use digital technology, and use digital technology to learn. The provision of this tool to teachers is likely to assist them to better understand the nature of digital literacy for their students with disability, and to have an increased awareness of the current abilities of these students and what they are likely to be ready to learn next. This information can be used to develop targeted teaching and learning programs to support students with disability to develop the digital literacy skills needed to access learning in the 21st century.

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Appendix

Pathway of digital literacy development for students with disability
6. Taking control of digital technology through guidelines and organisation
The student is learning to control and manage his/her use of digital technology, including device use, file management, sharing and editing content, and is developing a sense of personal relevance with the use of digital technology. S/he is beginning to make and explain decisions about how he/she uses technology, and may offer reasons for using a selected device or program/app over another. The student is starting to explain the purpose and personal importance of following rules or guidelines for the safe use of digital technology, and may demonstrate control over his/her use of digital technology by limiting his/her use to achieve personally relevant or set outcomes. The student is learning to manage files and folders to enhance organisation, and to edit text, images, video and/or audio to create finished products. S/he is beginning to upload and download files, and may explain or expand on different ways to do so.
5. Applying strategies and guidelines to digital technology use
The student is learning to identify and apply strategies and guidelines to improve the effectiveness of his/her use of digital technology, including to select the appropriate device or program/app for a task, and to address issues with devices or program/apps. The student is learning to use strategies like search terms to find desired information or content located on a device or the internet. S/he is beginning to follow cues or guidelines to name and save files. The student may be able to focus his/her attention to use a familiar device or program/app for personally relevant purposes, and persist in doing so despite distractions. S/he is starting to maintain attention when working with new or unfamiliar devices or programs/apps. S/he is beginning to list rules or guidelines for the safe use of digital technology, and may apply prior knowledge of safe handling procedures to care for familiar devices.
4. Using prior experience and procedures to complete tasks with digital technology
The student is learning to apply prior knowledge of familiar digital technology, and may explore new functions of devices or programs/apps and identify unfamiliar symbols by drawing on this knowledge. S/he is starting to follow rules, group procedures, and step-by-step instructions to create and save his/her own content. The student is beginning to focus on and follow instructions from a device or program/app to complete a task. S/he may express likes and dislikes about digital technology, and is beginning to use digital technology terms to describe his/her actions or intentions. The student may demonstrate responsibility for his/her use of digital technology by following explicit rules when using it, including following group procedures to stop using digital technology. S/he is

learning to demonstrate safe handling and storing procedures with familiar devices.
3. Engaging with digital technology and content to achieve own ends
The student is becoming aware of the use of digital technology to achieve his/her own ends. S/he may demonstrate this by maintaining interest in using a familiar device or program/app, engaging with information/content on devices, and by learning to create his/her own content. The student is beginning to demonstrate awareness that content can be located or saved on a device, and may request familiar or preferred content on a device. S/he is learning to repeat routines to care for a familiar device. The student is starting to follow single-step instructions which use familiar digital technology terms, and to identify the function of a familiar digital technology symbol.
2. Making connections with digital technology through interaction with devices and programs/apps
The student is learning to participate in digital technology-based activities that involve simple interactions between the student and the device or program/app. S/he is starting to follow single-step instructions to use a familiar device or program/app, and to make connections between his/her actions on the device or program/app and the effect. The student is beginning to develop an awareness of when a device or program/app is not working, and may alert others when this occurs. S/he may notice when something new or different is introduced via digital technology. The student is learning to respond to single-step instructions to stop using digital technology, and to recognise common symbols when using digital technology.
1. Reacting and responding to digital technology and content
The student is learning to react and respond to digital technology being used by another person, and to content on devices such as images or sounds. S/he is starting to interact with features of digital technology devices. The student is developing an awareness and acceptance of the use of some common devices or programs/apps.