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ORIGINAL ARTICLE

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# A framework for characterising and capturing the quality of digital interactions and experiences in early childhood education

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## Abstract

Understanding what constitutes quality in digital interactions within Early Childhood Education and Care (ECEC) settings has become paramount in an increasingly technology-enabled world. This imperative has grown, with diverse ingrained positions about the role of digital technology in ECEC, and limited evidence and guidance to support beneficial educator use with young children. This study introduces a Digital Interactions Quality (DigIQ) framework and scale as a protocol to observe and index the quality of interactions and experiences that involve digital technologies with children in ECEC settings. Informed by established frameworks for observation that are rendered into quality ratings, this research introduces a scale that considers children's interests and agency, opportunities for engagement, interactions and conversations, and digital transformations of play and learning. To evaluate this scale we conducted observations in 50 pre-school classrooms, guided by the DigIQ and Sustained Shared Thinking and Emotional Well-being scales, supplemented by in-depth field notes to characterise the range of current digital practices. By characterising and capturing the multifaceted nature of ECEC practice quality when digital technologies are involved, this framework aims to support educators, policymakers and researchers in making informed decisions about

digital integration in ECEC. The study underscores the need for differentiation in understanding quality in digital contexts to ensure use of digital technology serves as a meaningful extension and transformation to what traditional early childhood education practices already offer to children's outcomes.

**KEYWORDS**

digital technologies, early childhood education, interactions, learning, play, preschool, quality

## INTRODUCTION

Studying 'quality' in adult–child interactions is not a new phenomenon, and the benefits of 'quality' adult–child interactions are well established in educational theory and research (Fleer, 2010; Sylva et al., 2003). A recent systematic review examined the relationship between dimensions of quality adult–child interactions in early childhood education and care (ECEC) settings with various child developmental and educational outcomes, highlighting nuanced associations across different indices, contexts and study characteristics (Howard et al., 2024). However, the potential for and characteristics of 'quality' in adult–child interactions and experiences when digital technologies are involved is less clear. Most environmental and interactional quality measures are silent—and others implicitly pessimistic—about how digital technologies can be conducive (or incompatible) with high-quality pedagogy and practice. However, digital technologies are a reality in the lives of many children, which calls for a re-thinking of whether, how, when, for what, with whom, under what conditions, and with what characteristics digital technologies have a role in delivering high-quality adult–child interactions and early learning experiences. This may not be as straigthforward as generalising established quality principles to interactions and experiences that involve digital technologies. Although some quality indicators may translate well to interactions and activities involving digital technologies (e.g. pursuing a child's interests), others might not. Unique affordances and design features/limitations of digital technologies likely require specification of new characteristics and conditions of digital technology use in ECEC that are not currently conceived in existing theorising and measures of quality. The integration of digital technologies in ECEC is likely to continue unabated, presenting risks and missed opportunities if the principles and practices of effective use of digital technologies in ECEC remain assumed yet untested. In this context, principles refer to foundational ideas that can guide and justify practice, such as 'digital technologies can support children's learning across times and spaces'. Practices are an instantiation of these principles, for instance digital technologies being made available to support identification and discussion of native and invasive plant species whilst on a nature walk. The current study thus sought to conceive a framework to characterise the unique principles, practices and indicators of quality when digital technologies are used in ECEC with children and validate this model via a new scale of quality interactions and experiences surrounding the use of digital technologies.

The integration of digital technologies in early childhood education can be viewed through a sociocultural theoretical lens, which emphasises that learning is fundamentally an active social process mediated by language and interactions. Vygotsky (1978) highlighted the importance of learning with more knowledgeable others, such as educators, who scaffold children's development through intentional and responsive engagement. Rogoff (2008) subsequently emphasised the role of guided participation, and how children learn face-to-face

## Practitioner notes

### What is already known?

- Quality adult–child interactions in early childhood education and care (ECEC) settings influence child developmental and educational outcomes. However, the characteristics and conditions for high-quality digital technology use in ECEC are not sufficiently conceived in existing theorising and measures of quality.
- When used intentionally, digital technologies can support collaborative and language-rich interactions and learning experiences, but insufficient guidance is available around how educators might effectively initiate, structure and sustain interactions with children when digital technologies are involved.
- There is a need to articulate which known quality principles apply to digital contexts (e.g. pursuing a child's interests), and what novel considerations are additionally needed.

### What this paper adds?

- This study conceives a framework that characterises the unique aspects and indicators of quality when digital technologies are involved and validates this model via development of a novel Digital Interactions Quality (DigIQ) scale.
- The DigIQ scale provides a protocol for observing and indexing—along a progression of quality—children's digital opportunities, experiences and interactions in ECEC settings.
- By observing children's digital opportunities, experiences and interactions in 50 pre-school rooms across three Australian states and territories using the DigIQ scale, we propose and evaluate dimensions, continua and indicators of quality in adult–child interactions that involve digital technologies.

### Implications for practice and/or policy

- Findings provide guidance to support educators to increase quality practices whilst digital technologies are in use.
- Quality principles concerning digital technology use require new and additional practice considerations, as results suggest a nuanced relationship between general process quality and digital quality, whereby high digital quality was not always observed amongst high-quality services.
- Quality ratings were higher when learning and play intentions were the driver of activity, and digital technologies were leveraged when they could supplement or enhance those intentions. Quality ratings were lower when digital technologies were used as a stand-alone activity or to replicate what would have otherwise been done non-digitally. This indicates digital technologies should be purposefully integrated to enhance, modify or redefine the learning experience.

and side-by-side through active engagement with the guidance and support of more experienced others in the context of culturally meaningful activities. Both perspectives are aligned with the concept of Sustained Shared Thinking (SST) (Siraj & Asani, 2015), wherein educators co-construct knowledge with children through meaningful and extended dialogue

and joint exploration (Siraj-Blatchford, 2009; Verenikina et al., 2018), the practice of which is shown to support children's learning (Hamre et al., 2012; Kervin et al., 2026). Central is the role of language as both a communicative and cognitive tool, bridging both social interaction and cognitive development. As learning is scaffolded, children participate in cultural practices (Rogoff, 2008) and co-construct understanding in playful and inquiry-rich contexts (Siraj & Asani, 2015). Extended to digital technologies, these frameworks position digital experiences not as add-ons or replacements, but carrying potential to enhance, modify or redefine experiences (Puentedura, 2006) whilst mediating and connecting children to their context, learning opportunities and each other. When used intentionally, digital technologies support collaborative and language-rich interactions and experiences that extend beyond mere substitution of current analogue practices. Educator expertise, confidence and intentionality are thus critical for leveraging digital technologies to create meaningful and beneficial experiences in the early years (Hatzigianni & Kalaitzidis, 2018) that extend beyond learning to also involve social–emotional skills, agency, autonomy, self-regulation, collaboration and more.

The critical role of educators in shaping children's digital opportunities, experiences, skills and surrounding interactions is known (Dardanou et al., 2023; Konca & Erden, 2021). Whilst there are complex factors influencing the integration of technologies in ECEC (Bittner et al., 2018), educators' decisions regarding the use of space and materials, and the degree of educator control, have a 'profound effect on the affordances and constraints for interests to unfold' (Chesworth, 2019, p. 7). There has long been discussion surrounding children's active participation in adult-governed spaces (e.g. Broström, 2012) but the addition of digital technologies prompts us to consider what it means for children to participate in a society that is, prodigiously, digital. As inhabitants within 'digital lifeworlds' (Ergler et al., 2016, p. 133) children must be digitally literate, competent and indeed proficient. This is reinforced by educational curricula that task educators with use of digital technologies to facilitate learning (e.g. play, ask and answer questions, investigate, experiment), enact learning (e.g. represent thinking, document findings, express ideas, problem solve, connect, produce) and as a target of learning (e.g. digital literacy) (e.g. AGDE, 2022). Educator expertise is critical to realising these aims, influencing decisions about whether, when, how and for what purpose(s) technology is integrated into children's play and learning. The frontier of educational research is similarly shifting with children's increasing access to digital technologies (Lewis et al., 2024; Zack & Barr, 2016). However, there remains little research on what constitutes and characterises high quality—that is, beneficial for children's developmental progress and outcomes—adult–child interactions with digital technology (Danby, 2017; Lovato & Waxman, 2016; Troseth et al., 2016; Zack & Barr, 2016).

Action could not await this evidence. Children's educators (and parents) have needed to forge ahead, albeit not without significant angst and tensions—between pursuing digital interests of children (and often adults themselves), educational imperatives and pragmatic need on the one hand, but also uncertainty (e.g. which, when, how and for what purpose to use digital technology), contradiction (e.g. with 'screen time' guidelines), unanswered questions (e.g. what constitutes beneficial use) and stress (e.g. about making suboptimal decisions) (e.g. Mannell et al., 2025). With digital practices running ahead of evidence-based understandings, there is need to explore ways that adults initiate and structure, and respond to, interactions with children when digital technologies are involved. Whilst there is some guidance on thoughtful and effective use of digital technologies to support, for example children's relationships, well-being, play and citizenship (ECA, 2018), there is need for further research and for harmonisation with government policy and recommendations (AAP, 2016). Instead, and grounded in developmentally appropriate practice, government guidance for educators to effectively select and integrate digital technology tends to focus on intentionality of use,

equitable access and ongoing professional development (Donohue & Schomburg, 2017). There is need to identify evidence-based principles to understand, capture and grow quality of adult–child interactions and experiences involving digital technologies.

Indeed, children and educators are gaining increasing access to digital technologies in ECEC contexts and expectations of learning with, by and about digital technologies continues to increase. Despite calls to rethink ECEC curricula to take advantage of digital technologies (Siraj-Blatchford & Parmar, 2011; Yelland, 2011) and some recent efforts to increase expectations (e.g. version 2 of Australia's Early Years Learning Framework; AGDE, 2022), there remains insufficient guidance on how this is to be accomplished. Consequently, the full benefits of meaningful digital technology use relies on educators' willingness to understand and effectively incorporate digital technologies into their planning and practice. This study aims to support this effort by developing and validating in ECEC settings a framework that proposes principles, continua and indicators of quality in adult–child interactions that involve digital technologies. Although for brevity our scale refers to 'Digital Interactions Quality' (DigIQ), our focus is more accurately 'quality when digital technologies are involved'. '*Quality digital interactions'* or *'quality digital experiences'* implies the digital device is a focus of the activity. Rather, we aim to understand and foreground how principles and practices of quality change (or do not change) when digital technologies are involved—whether or not they are a substantial component of the experience. In this way, we consider the diverse uses for digital technologies, and recognise that experiences in which digital technologies are integrated are deeply influenced by social context and the presence, guidance and mediation of others.

# METHODS

## Participants

Forty-three ECEC services (providing 50 participating pre-school rooms) were recruited from three Australian states and territories. Parent organisations and stand-alone centres were recruited from the national ECEC network of the Early Start Institute, with which the authors are affiliated. Invited services were selected to ensure representation of the diversity of the ECEC sector in terms of: centre type (34 long daycare, 9 stand-alone pre-school), location (33 metropolitan, 9 inner regional, 1 outer regional), size (ranging from 16 to 124 approved child places), socio-economic profile (Deciles 1–9, based on the Australian Bureau of Statistics' Socio-Economic Indexes for Areas) and statutory national quality ratings (e.g. 16 rated as 'Exceeding', 21 as 'Meeting', 2 as 'Working Towards' and 2 as 'Provisional', which largely aligns with national trends of 90% of centres Meeting or Exceeding the National Quality Standard in 2025, albeit with a slightly higher prevalence of Exceeding centres in the current sample). Whilst six of the services had more than one room participate in the study, these rooms had separate educators, programs and processes. The Australian ECEC sector is characterised by regulations that establish a minimum requirement for staff qualification (at least one degree-qualified educator per room, with the rest of the room educators comprising a mix of degree, diploma and certificate qualifications) and staff: child ratios (1 educator per 11 children, from ages 3–5 years). All centres were compliant with these requirements. ECEC in Australia is guided by a national Early Years Learning Framework (V2.0), which offers shared understandings, capabilities and expected outcomes by the end of the pre-school years. The recent update to this Framework has increased reference and requirement to employ digital technologies to facilitate learning, enact learning and as a target of learning (AGDE, 2022).

## Measures

### Digital interactions quality (DigIQ) scale

Drawing on our theoretical perspective, which emphasises the centrality of language, social interaction and educator expertise in children's learning (Rogoff, 2008; Vygotsky, 1978; Vygotsky, 1986), a novel Digital Interactions Quality (DigIQ) scale was developed on the basis of our *Quality Digital Interactions* framework as a protocol for observing and indexing—along a progression of quality—children's digital opportunities, experiences and interactions within ECEC settings. This protocol was informed by established frameworks for observations that are rendered into quality ratings (including ECERS-R (Harms et al., 2015), ECERS-E (Sylva et al., 2003) and SSTEW (Siraj et al., 2015)), existing literature on characteristics of quality interactions (e.g. Howard et al., 2024), curricular frameworks, policies and guidance on digital practice in ECEC (e.g. AGDE, 2022; ECA, 2018), and multiple rounds of pilot and tool refinement.

This culminated in development of 14 items pertaining to children's digital opportunities, experiences and interactions in ECEC settings (the full scale is provided at Appendix A). Item ratings draw upon observational data to examine instances of quality interactions involving digital technologies—moments where educators and children collaboratively solved problems, extended narratives or explored concepts using digital technologies. We also considered adult–child verbal exchanges, focusing on content and relational dynamics of verbal and non-verbal communication. A post-observation conversation with educators regarding their intentions, approach, routines and unobserved practices supplemented observations. Reconciling these data sources, items were rated on a 4-point scale, each with a qualitative descriptor that, across the scale, characterises a continuum of quality practice for that dimension/item. A total DigIQ score was generated by calculating the mean of the 14 items. Planned analyses also sought to evaluate the possibility of conceptual dimensions (subscales).

Fieldworkers undertook in-depth training with members of the research team who led DigIQ development [LK and SH]. This included half-day in-class training, joint practice ratings in service with follow-up comparison and discussion of ratings, and a joint observation with independent ratings that were subjected to inter-rater reliability checks. All fieldworkers exceeded minimum requirements of mean difference in ratings $<0.75$ ($M_d = 0.15$ points), within 1 point on at least 75% of items ($M = 100\%$ within 1 point, no scores more than 1 point different), correlation of $r > 0.70$ ($M_r = 0.90$) and ICC $> 0.70$ ($M_{ICC} = 0.90$).

### Sustained shared thinking and emotional well-being scale (SSTEW)

The Sustained Shared Thinking and Emotional Well-being (SSTEW; Siraj et al., 2015) scale is a measure designed to assess interactional quality in ECEC services. The scale was informed by prominent developmental theories and research evidence on the importance and characteristics of high-quality interactions for children's cognitive, emotional and social development. The SSTEW scale emphasises child-centred, developmentally appropriate practices that support children's progression into self-regulated, autonomous learners through relational and intentional pedagogy (Howard et al., 2020). The SSTEW scale consists of 14 items distributed across five subscales: Building Trust, Confidence and Independence (4 items); Social and Emotional Well-being (1 item); Supporting and Extending Language and Communication (4 items); Supporting Learning and Critical Thinking (4 items); and Assessing Learning and Language (2 items). Each item is rated by indicating whether there was sufficient evidence (from observation, documentation

and discussions with educators) to indicate the presence of relevant indicators. These dichotomous yes or no decisions are then subjected to a scoring procedure that generates a quality rating score along a 7-point scale, with higher scores denoting higher quality. Subscale scores are generated by calculating the mean of relevant items, whilst a total score is derived by calculating the mean across subscale scores. The SSTEW scale has shown high concurrent validity with other environmental rating scales (e.g. ECERS-E) and SSTEW scores are predictive of various child developmental outcomes (e.g. numeracy, prosocial behaviour; Howard et al., 2022). All fieldworkers exceeded minimum requirements of mean difference in ratings <0.75 ($M_d = 0.21$ points), within 1 point on at least 80% of items ($M = 87.5\%$ within 1 point, no scores more than 1 point different), correlation of $r > 0.70$ ($M_r = 0.79$) and ICC > 0.70 ($M_{ICC} = 0.85$).

### Qualitative observations

Field notes were taken to systematically capture researcher observations regarding the nature of educator–child interactions during observation periods. These were taken in real time and guided by researcher knowledge of interactional quality in the SSTEW and DigIQ scales. The Technological Pedagogical Content Knowledge Framework (TPACK; Mishra & Koehler, 2006) and Substitution, Augmentation, Modification, Redefinition Framework (SAMR; Puentedura, 2006, 2014) were drawn upon to understand how digital technologies were incorporated into experiences. TPACK's focus on content, pedagogical and technological knowledge provided opportunity to examine how technology was integrated in ways that were appropriate to the developmental needs of the children, aligned to ECEC curricula and drew upon evidence in pedagogical practice. The SAMR ladder of technology integration enabled consideration of how educators moved beyond replacement-level use of technology towards transformative practices that foster creativity, collaboration and agency. In this paper qualitative observations are used to provide illustrative examples that show not only the presence of digital technologies, but also the intentionality behind its use, the educator–child interactions and emerging and realised possibilities.

## Procedure

Observation of each of the 50 pre-school rooms was conducted by one of four fieldworkers, trained to reliability, over a half day (either the morning or the afternoon session, according to the service's preference). Fieldworkers were members of the authorship team, with experience in early childhood education and child development, as well as prior experience using a variety of quality rating scales. Following the SSTEW and DigIQ observation protocol, researchers took on a fly-on-the-wall approach (Howard et al., 2019), ensuring they did not interfere with the usual practices and interactions in the room. Services were asked to engage in normal routine practice but, given our research focus—if possible and if part of typical practice—to include at least one example of how they use digital technologies in their practice. It was emphasised that, if included, the digital activity should be as authentic and typical as possible. No additional information was provided to services about the sort of practices we were interested in; rather, it was emphasised that we wanted to see what a typical day looks like in that room. Researchers took field notes as they systematically documented their observations and insights during each observation period. At the conclusion of the observation, researchers also had a 20–30-min conversation with the Director or the Room Leader, to elicit

information about plans and practices that could not be observed (e.g. other common uses of digital technologies and their frequency). In addition, researchers accessed assessment and planning records and other relevant information around the room (e.g. day books, floor books). Ethical approval was obtained from the University of Wollongong Human Research Ethics Committee (HREC # 2024/135). All room educators and service directors provided written consent to participate in the study.

# RESULTS

## Exploratory factor analysis

Exploratory factor analyses (EFA) were first conducted on DigIQ data to identify potential subscales. EFA used maximum likelihood estimation and direct oblimin factor rotation, due to expected correlation between extracted factors. Kaiser–Meyer–Olkin (KMO) statistics indicated sufficient sampling (KMO = 0.88). The significant Bartlett's test of sphericity ($p < 0.001$) indicated inter-item correlations were sufficiently large to justify EFA. The number of factors extracted was considered based on eigenvalues >1 (Kaiser, 1960) and inspection of screen plots. Assignment of items to factors was decided by factor loadings (>0.30) and theoretical justification (in terms of cross-loading). Eigenvalues indicated a strong first factor that accounted for 50.2% of variance in the data, whilst two additional factors had an eigenvalue >1 (accounting for 9.9% and 7.5% of the variance). The screen plot was equivocal in suggesting a 1- or 3-factor solution. The 3-factor solution was complicated by: widespread and strong cross-loading across factors; second and third factors with only 2 items loading most highly on those factors; clustering that did not have clear theoretical justification; and first factor reliability that was only slightly lower ($\alpha = 0.916$) than the full-scale score ($\alpha = 0.920$). Accordingly, results point to a 1-factor DigIQ scale score (rather than separable subscales), and subsequent analyses considered only this full-scale DigIQ score.

## Associations between quality practice and quality digital practices

There was a strong positive association between DigIQ and SSTEW total scores, $r = 0.63$, $p < 0.001$, with higher SSTEW quality ratings tending to coincide with higher DigIQ quality ratings. Associations discriminated well and remained non-perfect, in expected patterns across the SSTEW subscales, supporting that this association was not merely a product of conflated general quality indicators. That is, DigIQ correlated with SSTEW subscales as follows:(in descending order of association strength): *Supporting Learning and Critical Thinking*, $r = 0.71$, $p < 0.001$; *Building Trust, Confidence and Independence*, $r = 0.58$, $p < 0.001$; *Supporting and Extending Language and Communication*, $r = 0.57$, $p < 0.001$; *Assessing learning and language*, $r = 0.42$, $p < 0.001$; and *Social and Emotional Wellbeing*, $r = 0.40$, $p < 0.001$.

The expected imperfect relationship between general pedagogical and interactional quality with quality of digital experiences and interactions was also supported by inspection of scatterplots (see Figure 1). These showed that pedagogical and interactional quality was a necessary condition for digital quality, as evidenced by consistently low DigIQ scores amongst rooms with low SSTEW ratings. Indeed, no rooms with a SSTEW score below 3 (typically characterised as below 'minimal' or 'basic' quality) received an average DigIQ rating above 2. Yet digital quality (or much digital integration at all) was not a precondition of pedagogical and interactional quality, as indicated by rooms scoring well on SSTEW but low on DigIQ (the white circles in Figure 1). Several rooms scoring well on SSTEW (e.g. at

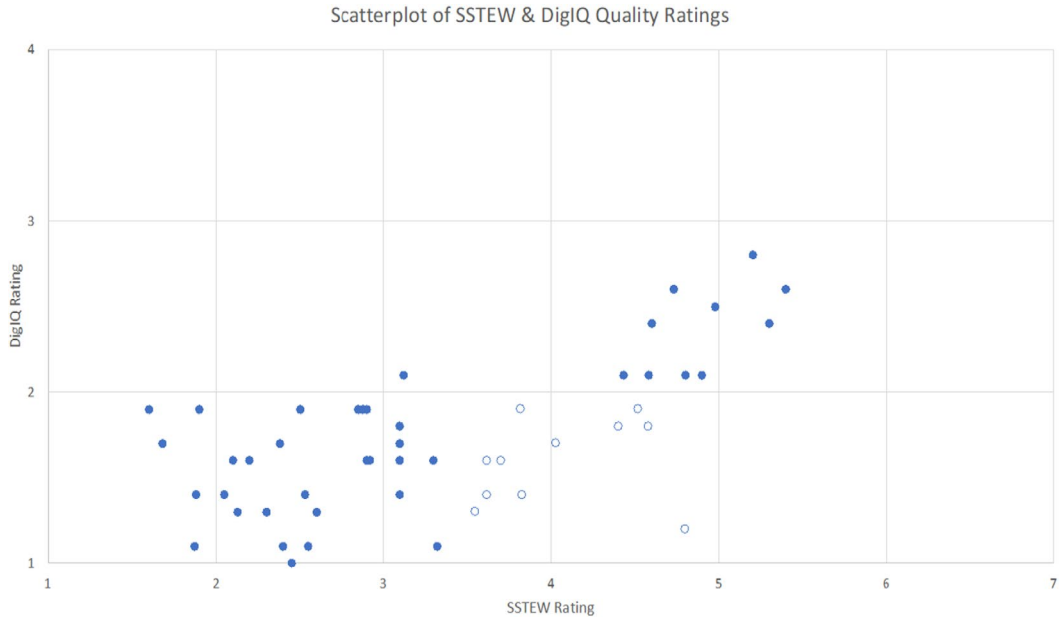


**FIGURE 1** Scatterplot of SSTEW and DigIQ quality ratings. Blue dots identify rooms that are broadly consistent with a prediction of linear association of digital quality with pedagogical and interactional quality. White dots identify rooms that diverge from this pattern, exclusively in a direction of higher quality practices (as indicated by SSTEW) but lower-quality (or absent) digital practices.

or around a score of 5, which is typically viewed as 'good' quality) exceeded a mean of 2 on DigIQ. However others at this same level of quality showed little digital activity or lower-quality practices when they did. In short, good knowledge and enaction of quality practice was required for quality of digital practices, although high-quality practice was not reliant upon digital integration or quality.

## Exploration of DigIQ digital quality ratings

Descriptive statistics for DigIQ total and item scores are reported in Table 1. DigIQ total scores were normally distributed, as indicated by a non-significant Shapiro–Wilk statistic ($p = 0.159$). These scores ranged from 1.00 to 2.79, with a mean DigIQ rating of 1.72. Overall, whilst our data demonstrated that good quality digital opportunities, experiences and interactions were possible (the maximum DigIQ total rating in our sample was 2.79 of a possible 4), the general trend was towards low digital integration and typically lower-quality practices when digital technologies were used.

### Items with uniformly low quality ratings

There was a set of items for which quality ratings were consistently low across the sample: Item 7 on communication affordances, Item 8 on promoting digital self-regulation and safety, Item 12 on seamless integration and Item 14 on use to spark and pursue curiosity. Practices related to these items were rarely seen during observations. For example, there was little discussion or modelling to promote digital self-regulation and safety (Item 8), such as asking consent before taking somebody else's photograph or discussion of digital safety and

**TABLE 1** DigIQ descriptive statistics for total and item scores.

| | | M (SD) | Min | Max |
|---|---|---|---|---|
| **Item** | **DigIQ total** | **1.72 (0.43)** | **1.00** | **2.79** |
| 1 | Educators position themselves as digital learners | 1.90 (0.74) | 1 | 4 |
| 2 | Educators' digital proficiency allows flexible and meaningful use | 2.00 (0.40) | 1 | 3 |
| 3 | Digital technologies are available to support children's learning and play across times and space | 1.66 (0.69) | 1 | 3 |
| 4 | Digital technologies are used flexibly and intentionally across child groupings to support learning and play | 2.00 (0.70) | 1 | 3 |
| 5 | Children take an active role in digital aspects of learning and play experiences | 1.70 (0.74) | 1 | 3 |
| 6 | Digital technologies are used to pursue children's interests | 2.00 (0.57) | 1 | 3 |
| 7 | Learning and play experiences explore the connection and communication affordances of digital technologies | 1.32 (0.51) | 1 | 3 |
| 8 | Children learn digital self-regulation skills and strategies to promote safe and productive digital activity | 1.26 (0.49) | 1 | 3 |
| 9 | Digital technologies are used to enable high-quality interactions | 1.52 (0.65) | 1 | 3 |
| 10 | Digital technologies contribute to adult–child and child–child conversations during and surrounding learning and play | 2.04 (0.64) | 1 | 3 |
| 11 | Digital technologies are used to extend, supplement and/or transform non-digital learning experiences | 1.80 (0.73) | 1 | 3 |
| 12 | Digital technologies are seamlessly integrated into learning and play experiences | 1.52 (0.58) | 1 | 3 |
| 13 | Digital technologies are used to enable children's meaningful engagement and creation | 1.78 (0.55) | 1 | 3 |
| 14 | Digital technologies are used to spark and pursue children's curiosity, wonder and exploration | 1.64 (0.60) | 1 | 3 |

privacy with children. There was also a common disjointed experience when digital technologies were involved, rather than the seamless integration of digital technologies in support of children's learning and play experiences (item 11). That is, often when digital technologies were used this was as a stand-alone activity, such as independent play for a predetermined time (e.g. 15 min) with pre-selected apps or as an 'bolt-on' to other experiences. In the latter, children were often requested to redirect their attention to a digital device—usually in silence (e.g. watching a pre-selected YouTube clip)—rather than smooth transitions between digital and non-digital play (as is characteristic of, for example dialogic book reading where an adult moves seamlessly in and out of story reading and discussion).

## Items with highly variable quality ratings

Another set of items showed high variability in ratings and practices observed: Item 2 on flexible use across time and space, Item 5 on children's active role, Item 9 on high-quality interactions, Item 11 on transforming non-digital experiences, and Item 13 on meaningful child engagement and creation. For instance, in relation to flexible use of digital technologies across time and spaces (Item 2), practices ranged from iPads being placed out of reach

of children and not available for play, to designated digital spaces (e.g. office corner or even a particular chair) where digital play was usually independent and timed (e.g. turn taking with a pre-selected app), to ready access to iPads or other digital tools for flexible play indoors. Similar variability was also observed in how digital technologies were used to facilitate high-quality interactions (Item 9). In many rooms, digital technologies disrupted educator–child interactions—for example as educators used iPads for documentation (e.g. photos, learning stories, record keeping) in the moment. In other rooms, digital technologies had very little or no impact on interaction quality—for some, this was because interactional quality was already limited, but for others because digital technologies were already meaningfully integrated into play and learning experiences. For some rooms, when digital technologies interrupted interactions, they were later drawn upon to enhance the discussions during follow-up activities (e.g. watching a YouTube clip on a topic of interest, the content of which was used to enrich later discussions). This appeared to vary more between rooms, yet was quite consistent across time and activities within a room.

### Items with comparatively higher quality ratings

Finally, higher quality ratings were more consistently achieved on a third set of items: Item 1 on educators as digital learners, Item 6 on pursuing children's interests, Item 4 on flexible use across groupings and Item 10 on contributing to conversations. Digital technologies were often used to pursue children's interests (Item 6), for instance using an iPad to help respond to a child's question or observation—such as researching an unusual bug they noticed in the yard—either in the moment or in follow-up activities. Educators across many rooms demonstrated a positive inclination and enthusiasm in using and learning more about digital technologies (e.g. actively seeking out professional development or information from reputable sources; Item 1). However, it was not always the case that this learning transferred to practices assessed in other DigIQ items. Indeed, despite this enthusiasm, educators sometimes were constrained by their organisation (e.g. policy restrictions on use of digital technologies, limits on which apps can be used), families (e.g. parent expectations of no or low screen time in ECEC), leadership (e.g. local priorities, tablets for educator use only), availability of digital resources (e.g. little or broken equipment and high cost to acquire or replace these) and/or limited access to Wi-Fi constraining possible uses.

## DISCUSSION

This study aimed to identify dimensions and empirically evaluate indices of effective use of digital technologies in ECEC contexts. If achieved, this would contribute to bridging the divide between curricular imperatives to cultivate safe, productive digital citizens, yet low guidance on practices by which to achieve this aim. Results indicated that the DigIQ scale had strong concurrent and discriminant validity with an established environmental quality rating scale (the SSTEW scale), supporting its consistency with quality principles and practices without merely being underpinned by a common core of quality. Results further indicated that high process quality was a precondition for high digital quality, although the reverse was not also true—high digital quality was not always observed amongst high-quality services. Rather, digital practices were found to be highly variable, even within rooms with higher process quality, with clear areas of relative strength and other areas of high variability or low activity. Together, findings provide targets and tools to support educators to increase quality practices whilst digital technologies are in use.

Reference to 'quality whilst digital technologies are in use' is intentional, rather than *quality digital interactions* and *quality digital experiences*. In the latter cases, digital technologies appear as a focus of the interaction (e.g. communication using a digital device) or activity (e.g. activity on a digital device). However, we propose and find that quality ratings are higher when learning and play intentions are the driver of activity, and digital technologies are used to supplement or enhance those intentions, to offer new and transformative possibilities to learning, interaction and participation. Indeed, quality ratings were lower when digital technologies were used as a stand-alone activity or to replicate what would have otherwise been done non-digitally (e.g. drawing and colouring apps). In these cases where activity was driven by digital technologies, rather than in service of learning intentions and aspired outcomes, the activity was often solitary (e.g. 15 min of solitary play on a selected app), a sole focus (e.g. watching a video clip) and/or came with an expectation of quiet attention (e.g. in group time, children watching on as each child took a turn playing a number identification game on a digital interactive whiteboard). The consequence of this was often lower-quality ratings when digital technologies were in use. It implies a need for a more systemic consideration and approach to technological integration—what, when, why, how and with whom digital affordances are leveraged—that considers development more holistically.

Lower-quality ratings in these instances was partly a function of DigIQ items that expressly rated dimensions of seamless integration and extension. Seamless integration of complementary resources to support and extend learning intentions is a common characteristic in quality practice frameworks (e.g. Siraj et al., 2015), to enable experiences, interactions and conversations that would not otherwise be possible. Within the SSTEW scale, for instance, indicators for promoting social and emotional well-being at the highest level of quality include using stories and props to support children to talk about their feelings—thereby changing the nature, quantity or continuity of conversations. Yet digital technologies were often deployed differently than other learning supports, like books or blocks, with digital technologies often constraining interactions because they were used as a solitary, sustained and silent focus (in contrast to, for example simple omission as would be the case in discussing feelings without aid of a story). This palpable separation of digital from analogue activity impacted scores lower on other items too—such as pursuit of child interests, conversations, exploration and creation—leading to lower overall quality practices and indices. The finding of high-quality ratings when digital activity was planned as a complement to enrich learning experiences and outcomes, whilst engaging children and educators in communicative and relational purposes, indicates that this situation of lower quality whilst digital technologies are in use is not inevitable.

Results instead point to a nuanced relationship between general process quality and quality of interactions and experiences when digital technologies are involved. Indeed, process quality was a necessary precondition for 'digital quality', but the reverse was not also true. High process quality could—and often did—coexist with low digital quality ratings. Whilst both SSTEW and DigIQ rely on a similar base of quality principles—for example intentionality, sustained shared thinking, authentic conversation, learning through play, enhancement over substitution, active over passive—there are a few reasons they might diverge. First, it may be the case that digital quality principles require new and additional practice considerations. For instance, current quality and pedagogical frameworks offer little guidance on when it is beneficial (and when it is not) to employ digital technologies, how these might be effectively integrated with learning intentions and be embedded within values, affordances and constraints that influence children's experiences and possibilities. Similarly, cultivating self-regulation skills through which children increasingly direct and control their own digital activities is a more recent aspiration, which as yet lacks clear evidence and guidance to achieve (Howard et al., 2022). Accordingly, there is need to articulate which known quality principles apply to digital contexts and how (e.g. following children's interests,

offering opportunities for child agency and autonomy, importance of conversations and joint engagement with digital technologies) (Mallawaarachchi et al., 2024), as well as the novel considerations that are additionally needed (Fleer, 2018; Samuelsson et al., 2022), such as educator and child digital dispositions and proficiency, fostering digital self-regulation skills, seamless integration of analogue and digital aspects within learning and play experiences, digital technologies that enable rather than constrain, and social and cultural responsiveness. Although pedagogical frameworks exist, these require adaptation to ECEC and further articulation with digital opportunities (Dardanou et al., 2023). In particular, Dardanou et al. (2023) emphasise the importance of digital competencies and attitudes, supported by evidence-based professional development that stimulates educators to be reflective, collaborative and consider use of digital technologies in ECEC more holistically and systemically.

Second, it is true that high quality—as measured by tools such as the SSTEW scale—does not require high-quality digital practices (as demonstrated by ours and others' findings; Hatzigianni et al., 2023). Indeed, research has found at least some resistance to the use of digital technologies, by educators and by parents (Schriever, 2021). However, in these cases it is difficult to discern how and where curricular imperatives to support children's learning to use digital technologies in safe, productive, healthy ways are being achieved (e.g. AGDE, 2022). This situation is set against a current climate of concern—about high and interrelated rates of problematic digital activity and behaviours, child mental ill-health, classroom disruption and declines in educational outcomes (Howard et al., 2026; RACGP, 2024). Current concern is so great that attempts to influence children's digital activity through 'screen time' guidelines (AGDH, 2018; AGDHA, 2004) have more recently been supplemented by bans on use of digital technologies in particular contexts—for example on mobile phones in schools (Victoria Government, 2023) and child access to social media (Prime Minister of Australia, 2024). There is a clear imperative to better prepare children to self-regulate their digital activity: to maximise their educational experiences, exercise discretion in risky and manipulative digital contexts (eSafety Commissioner, 2024) and establish foundations for their rights to a free and full life (UN Committee on the Rights of Children, 2021). So, whilst it is indeed possible for high-quality practices to coexist without any digital technologies, there is a strong case that proceeding without regard for digital technologies is underpreparing children for the realities of a future in the 21st century (McCoy & Sabol, 2025).

Third, it may also be the case that knowledge and enaction of process quality principles does not simply convey to high-quality digital practices—even those shared between experiences with and without digital technologies. Taking the example of adult–child interactions, it is not inherently clear how to thread conversation whilst digital technologies are in use—particularly given design features that encourage solitary use and dedicated attention (e.g. personal device, multimedia content without natural breaks, time and technological know-how to navigate) (Livingstone et al., 2025). There is need for professional learning not only on the quality principles articulated here but also how this can be enacted for child benefit in ECEC contexts. These efforts may also require establishing a case for uses of digital technologies in ECEC at all, given strong opposition by some (in one case we observed, digital technology integration efforts by one educator were undercut by another who did not believe digital technologies had a role in ECEC, and accordingly would unplug the devices from charging before leaving each night). This DigIQ framework provides an initial roadmap to principles and practices (from, e.g. SSTEW indicators) of interactional quality when digital technologies are incorporated within ECEC, as well as insight into current strengths and opportunities.

Areas of relative strength parallel those found in research on process quality more broadly: educator commitment to continuous learning, a focus on children's interests, and a commitment to frequent and rich conversations with children about their play and learning (Kervin et al., 2025). Areas that warrant more concerted attention and effort include

fostering children's digital self-regulation and safety, seamless integration of digital into the analogue aspects of learning and play experiences, and use of digital technologies to enhance and transform experiences. According to the SAMR model, for instance, there is low to no benefit from simply substituting effective analogue activities for comparable digital versions (Puentedura, 2006). Indeed, this could cause a decrement in benefit due to, for instance, limitations of digital devices and their requisite technological know-how (Mishra & Koehler, 2006). Instead, the benefit of technological integration comes when technology enables significant enhancement via redesign or redefinition of the experience. One educator during our observations did this by leveraging the communication affordances of technology to bring parents virtually into the room to share their professional expertise—aligned with the room's current theme and focus—and provide formative feedback on children's productions. Efforts to promote quality practice whilst digital technologies are in use could be benefited by case examples such as these (Kervin et al., 2019; Kervin et al., 2026).

Although this study captures a large number of diverse ECEC settings, it is not reflective or representative of the broader ECEC sector (which includes pre-schools and family daycare settings). For instance, it is possible that study of targeted ECEC subsamples may indicate a different pattern of results; we have little basis in the current results on which to speculate these different patterns. This complicates definitive conclusions about digital quality across the sector, although it is not expected to moot the importance of the quality principles and practices within DigIQ. However, it may have obscured emergence of subscales, which were anticipated across dimensions of educator disposition and deployment, children's interests and agency, and the quality of interactions and experiences. There might also be other dimensions of digital quality we did not consider or are yet to emerge with new technologies (e.g. Artificial Intelligence, Virtual Reality). Finally, there is an inherent difficulty in validating a *digital* quality scale against child outcomes—as has been typical practice with other quality rating scales (e.g. Howard et al., 2019; Sylva et al., 2006)—because of the finding that process quality (and child growth) can exist without digital quality. Whilst it may be that digital quality stimulates growth in particular aspects of child learning (e.g. self-regulation of digital activities, safe digital practices), without decrement to other outcomes, availability of suitable measures of these abilities lag behind. Or, digital technologies may indeed enhance child outcomes more broadly (e.g. in language, early mathematics), beyond impacts of ECEC, although a sizeable sample would be needed to detect this expectedly small incremental effect (Sylva et al., 2004). Another area for urgent attention is the design and evaluation of professional development to instil high-quality practices when digital technologies are involved (Dardanou et al., 2023). At present, consequences of generally low digital quality is unknown, yet current digital trends allow us to glimpse potential futures if we stay our current course (see our earlier comment re: climate of concern).

In the context of increasing digital concern and restriction—yet also increasing ubiquity and use that outpaces evidence—there exists an imperative to prepare and equip children for a future that is inextricably digital, in which they must be able to make safe, productive, beneficial digital decisions (Kervin et al., 2026). This requires more than simply tasking this to educators and families, but rather requires concentrated and orchestrated efforts to generate meaningful evidence and develop guidance to support beneficial digital practice. This research provides important orientation and foundation to these aims, characterising quality when digital technologies are in use, as well as targets, continua and exemplars for professional development to support continuous quality improvement. Our findings suggest that fundamental attention must continue to be paid to quality as traditionally understood in ECEC, yet upon this educators can be supported to develop a supra-layer of digital quality. Whilst we might expect that these principles of digital quality will continue to grow and evolve—as will technologies themselves—it is not expected that established principles

concerning child agency, self-regulation, interaction and opportunity will be erased by these evolutions.

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## CONFLICT OF INTEREST STATEMENT

The authors report there are no competing interests to declare.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request. Restrictions apply to the availability of these data due to [e.g. participant confidentiality, ethical approval].

## ETHICS STATEMENT

This study was reviewed and approved by the University of Wollongong Human Research Ethics Committee (HREC # 2024/135). All room educators and service directors provided written consent for the observations.

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## APPENDIX A

### DigIQ Scale, 2026

**1. Educators position themselves as digital learners**.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Educators are negatively inclined towards and avoid learning about or using, digital technologies. | Educators access provided information but with no real positive inclination to learn or implement. | Educators seek, engage with and implement information and/or professional learning about digital technologies. | Educators seek, engage with, critically reflect upon and implement information about digital technologies and model positive interest and thinking. |

**2. Educators' digital proficiency allows flexible and meaningful use that suits well the learning or play experience**.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Educators do not show a clear understanding of the functionality of their digital technologies, which constrains use and associated activity. | Educators show a basic understanding of their digital technologies, which permits effective use of its more basic functions. | Educators show good knowledge of their digital technologies, and they use diverse digital resources and/or functionalities to support learning and play. | Educators are adept at using digital technologies and use this knowledge to engage in flexible and meaningful use that enriches or extends learning and play. |

**3. Digital technologies are available to support children's learning and play across times and spaces**.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital technologies are rarely or never available for children's use. They are only used by adults or not at all. | Children's opportunities to use digital technologies are constrained to a few specific locations and/or times. | Children have opportunities to use digital resources to support their learning and play across several constrained spaces and times. | Digital technologies are available to support children's learning and play flexibly across the available spaces and times. |

### 4. Digital technologies are used flexibly and intentionality across child groupings to support learning and play.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital technologies are never used to support children's learning and play and/or only used for entertainment. | When digital technologies are used for learning and play, they are confined to only whole-group time; or some small-group with minimal educational purpose. | Digital technologies are used with smaller groups or with individuals, with educational purpose. | Digital technologies are used with smaller groups or with individuals, with intentionality that advances the learning or play. |

### 5. Children take an active role in digital aspects of learning and play experiences.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Children do not take an active role in digital aspects of an experience. | Children take an active role in facilitating *some* aspects of the digital technologies, although children's digital activity remains largely directed by the educator. | Children take an active lead role in using digital technologies. | Children are well supported to lead and meaningfully direct a range of digital learning and play experiences. |

### 6. Digital technologies are used to pursue children's interests.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital technologies are not used with children, even when they could support the pursuit of children's interests. | Use of digital technologies is directed predominantly by a curriculum or the centre's and/or educator's priorities. | Digital technologies are used in ways that meet a few children's genuine interests, which may or may not be offered to other children. | Digital technologies are used in ways that are differentiated to meet most children's genuine interests. |

### 7. Learning and play experiences explore the connection and communication affordances of digital technologies.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Connection and communication affordances of digital technologies (e.g. to home, community or an audience) are never or very rarely discussed with children. | Connection and communication affordances of digital technologies are discussed with the children but are not acted upon or are a tokenistic aspect of the activity. | Connection and communication affordances of digital technologies are explored with the children, and these are integrated to the activity. | Connection and communication affordances of digital technologies are explored with the children and transform the activity. |

### 8. Children learn digital self-regulation skills and strategies to promote safe and productive digital activity.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Children do not learn about safe and productive use of digital technologies. | Children learn about safe and productive use of digital technologies, but this is rarely modelled. | Children are provided with explicit modelling and practice around safe and productive use of digital technologies. | Children are provided with explicit, active learning and experiences that seek to promote knowledge, skills and strategies for safe, productive and self-regulated use of digital technologies. |

### 9. Digital technologies are used to enable high-quality interactions.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| None or few features of high-quality interactions are evident during use of digital technologies. | Some features of high-quality interactions are evident during or surrounding the use of digital technologies. | Many features of high-quality interactions are evident during or surrounding the use of digital technologies. | Digital experiences are well leveraged to engage in diverse, high-quality interactions with children. |

### 10. Digital Technologies contribute to adult–child and child–child conversations during and surrounding learning and play.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital technology is either not used or regularly used in ways that are a barrier to conversations. | Limited conversation occurs during use of digital technologies. | Conversations continue during and surrounding digital technology use. | Digital technologies are used to instigate novel conversations, sustaining, extending or enhancing interactions. |

### 11. Digital technologies are used to extend, supplement and/or transform non-digital learning experiences.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital technologies are used as a substitute for another activity, without tangible improvement over the non-digital alternative. | Digital technologies are used to substitute a non-digital activity, with the digital option offering a functional improvement over its non-digital alternative. | Digital technologies are integrated to supplement an activity, adding new aspects or angles that would not be possible otherwise. | Digital technologies are used to enable entirely new experiences and activities, such that the task would not be possible without its digital inclusions. |

### 12. Digital technologies are seamlessly integrated into children's learning and play experiences.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital technologies are used as a stand-alone activity in isolation from children's non-digital learning and play. | There are digital and non-digital aspects in the same learning experience or play, with their transition clearly demarcated. | Digital technologies are integrated into activities, with flexible and less noticeable transitions between them. | Digital technologies are seamlessly integrated into activities, with effortless and flexible transition in and out of digital. |

**13. Digital technologies are used to enable children's meaningful engagement and creation**.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital technologies are either not used or, when they are, they are rarely invoked again for learning or play. | Passive digital experiences are used in a minor way to inform learning or play and/or children participate in only rudimentary digital tasks. | Children use digital technologies as an instrumental tool to help inform their thinking or learning and/or to facilitate imaginative play through generating new ideas, explorations or questions. | Children actively produce using digital technologies – generating, creating and/or combining using digital and non-digital resources to create a new product, process or outcome. |

**14. Digital technologies are used to spark and pursue children's curiosity, wonder and exploration**.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Digital devices are neither used to stimulate nor pursue children's curiosity or exploration. | Digital technologies are used to pursue children's curiosity, usually briefly and constrained to what is essential to support non-digital explorations. | Digital technologies are used to pursue children's curiosity with digital explorations that are deeper, repeated and sustained. | Digital technologies are used to stimulate and then pursue children's curiosity by providing digitally supported experiences that evoke curiosity, wonder and exploration. |