The Impact of Nursery Teachers' Digital Literacy on the Quality of Responsive Caregiving: The Mediating Role of AI-Assisted Observation Self-Efficacy

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Abstract. This study examined whether nursery teachers' digital literacy predicts the quality of responsive caregiving in technology-enhanced childcare settings and whether AI-assisted observation self-efficacy mediates this relationship. In contemporary nursery institutions, intelligent observation systems, digital records and data-based feedback tools are increasingly embedded in daily care routines. Under such conditions, teachers are expected not only to operate digital tools but also to translate digital information into sensitive, timely, and developmentally appropriate responses to infants' and toddlers' cues. A total of 346 nursery teachers from institutions in Beijing and surrounding areas who routinely used intelligent observation systems participated in the survey. Digital literacy was measured with a revised 15-item scale, AI-assisted observation self-efficacy with a 12-item adapted scale, and responsive caregiving quality with a 12-item self-report measure derived from the CLASS Infant and Toddler frameworks. All measures demonstrated acceptable reliability and construct validity. Correlational analyses indicated that digital literacy, AI-assisted observation self-efficacy, and responsive caregiving quality were positively associated. Mediation analysis using PROCESS Model 4, controlling for age and years of teaching experience, showed that digital literacy positively predicted AI-assisted observation self-efficacy, which in turn positively predicted responsive caregiving quality. The indirect effect was significant and accounted for 36.4% of the total effect, indicating partial mediation. These findings suggest that digital literacy functions not only as a technical competence but also as a professional resource that helps nursery teachers use AI-supported observation to strengthen responsive caregiving. The study extends research on teacher digital competence from instructional outcomes to caregiving quality and highlights the importance of combining digital-skills training with efficacy-building support in nursery digitalization.

Keywords: nursery teachers, digital literacy, AI-assisted observation self-efficacy, responsive caregiving, early childcare

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1 Introduction

The rapid expansion of digital technology has significantly reshaped the ecology of early childhood education and care. In nursery settings, teachers increasingly work with digital documentation systems, intelligent observation platforms, AI-supported behavior recognition tools, and data-based feedback mechanisms. Recent scholarship suggests that digitalization in early childhood settings is no longer limited to device availability; rather, it involves teachers' capacity to interpret digital information, make pedagogically sound judgments, and integrate technology into child-centered practice [1–3]. In this context, the professional meaning of teachers' digital literacy has broadened from operational skill to situated competence within everyday care and interaction.

Among the core responsibilities of nursery teachers, responsive caregiving occupies a central position. Responsive caregiving (RC) refers to adults' ability to accurately notice infants' and toddlers' cues, interpret their needs accurately, and provide prompt, appropriate, and emotionally supportive responses [4, 5]. High-quality responsive caregiving supports attachment security, emotional regulation, language development, and social competence, and is widely recognized as a central dimension of process quality in infant–toddler care [4, 9, 10]. As childcare environments become increasingly information-rich, teachers' responsiveness may depend not only on interpersonal sensitivity but also on their ability to access and use digital information relevant to children's needs, routines, and developmental trajectories.

At the same time, AI-assisted systems are changing how observation is conducted in nursery institutions. Digital observation tools can support the recording of behavioral patterns, routines, participation, and emotional signals across time, while platform-based dashboards can generate summaries to aid reflection and communication. Yet these systems do not automatically improve practice. Their value depends on whether teachers can interpret the information meaningfully and translate it into developmentally appropriate caregiving responses. This means that the quality of digitalized childcare is shaped not only by technology itself but also by teachers' competencies and beliefs when using it [2, 6, 11].

One important competency in this regard is digital literacy. Digital literacy (DL) is generally understood as a combination of knowledge, skills, dispositions, and critical judgment that enables individuals to access, evaluate, create, and use digital tools effectively, responsibly, and reflectively [6, 7]. In educational settings, teacher digital literacy has been linked to technology integration, professional learning, and adaptive practice [6, 8]. In early childhood contexts, however, prior research has mostly focused on preschool teaching, digital play, or preservice preparation, while relatively less attention has been paid to nursery teachers working with infants and toddlers in care-oriented, observation-intensive environments [1, 2, 6]. This leaves an important gap, because nursery teachers' daily responsibilities differ substantially from those of teachers in more instruction-centered settings.

From an ecological perspective, the digital tools can be regarded as part of the teacher's proximal work environment in which teachers carry out caregiving. Ecological systems theory emphasizes that development and professional action are shaped by

ongoing interactions between individuals and their immediate environments [12]. In digitally enhanced nursery settings, teachers engage not only with children and families but also with records, platforms, alerts, and AI-supported summaries. Teachers with stronger digital literacy may therefore be better able to navigate this ecology, identify meaningful signals, and coordinate more timely and individualized responses. This reasoning suggests that digital literacy may positively predict responsive caregiving quality.

However, competence alone may not be sufficient to explain how digital literacy is translated into practice. Self-efficacy theory argues that individuals' beliefs in their ability to perform domain-specific tasks influence persistence, effort, and effective action [13]. In technology-related contexts, self-efficacy has repeatedly been associated with higher levels of adoption, more confident problem-solving, and better implementation outcomes [11, 13]. When AI-supported observation is introduced into nursery settings, teachers may differ not only in what they know, but also in whether they feel capable of using AI-generated information to observe children, interpret outputs, and make sound caregiving decisions.

This study therefore focuses on AI-assisted observation self-efficacy as a potential mediating mechanism. AI-assisted observation self-efficacy refers to teachers' confidence in their ability to use AI-supported systems to observe children, interpret digital outputs, and incorporate those outputs into professional judgment and responsive action. Theoretically, digital literacy may foster this efficacy belief by increasing successful experiences with technology, reducing uncertainty, and strengthening perceived control in observation-related tasks [11, 13]. In turn, stronger efficacy beliefs may make teachers more willing to engage with AI-supported feedback (AISE), persist when systems are complex, and use digital evidence in ways that improve the timeliness and sensitivity of caregiving responses.

Although a growing body of work has examined digital competence in early childhood education and AI-related self-efficacy in education, empirical evidence connecting these strands in nursery care remains limited [2, 3, 8, 11]. Existing studies have mainly concentrated on school teaching, preservice teacher preparation, or technology acceptance. Much less is known about whether nursery teachers' digital literacy contributes to caregiving quality, and even less is known about the psychological processes through which this may occur. This is a meaningful gap because digitalization in nursery settings is justified not by technological novelty itself, but by its capacity to support more responsive, individualized, and developmentally appropriate care.

Against this background, the present study examined the association between nursery teachers' digital literacy and responsive caregiving quality in information-rich childcare settings, with AI-assisted observation self-efficacy as a potential mediator. The study contributes to the literature in three ways. First, it extends research on teacher digital literacy beyond instructional outcomes to the quality of care in infant–toddler settings. Second, it introduces AI-assisted observation self-efficacy as a more proximal psychological mechanism linking digital competence to responsive professional action. Third, it provides empirical evidence that may inform digital professional development in nursery institutions, where investments in equipment must be matched by investments in teacher competence and confidence.

Based on the above reasoning, three hypotheses were proposed: H1, nursery teachers' digital literacy positively predicts responsive caregiving quality; H2, nursery teachers' digital literacy positively predicts AI-assisted observation self-efficacy; and H3, AI-assisted observation self-efficacy mediates the relationship between digital literacy and responsive caregiving quality.

2 Method

2.1 Participants

Participants were recruited from nursery institutions in Beijing and surrounding areas. These institutions had incorporated intelligent observation systems or AI-supported digital platforms into daily childcare practice. A total of 410 nursery teachers were invited to participate in the survey. After removing incomplete or invalid questionnaires, 346 valid responses were retained for analysis, yielding an effective response rate of 84.4%.

The participants were front-line nursery teachers engaged in the daily care and observation of infants and toddlers. Because the purpose of the study was to examine how teachers' technological and psychological resources are associated with caregiving quality in digitally enhanced environments, only teachers with routine exposure to digital observation or documentation systems were included. Participants varied in age and years of teaching experience, providing sufficient variability for the analyses.

2.2 Measures

Digital literacy: Nursery teachers' digital literacy was assessed using the Revised Digital Literacy Scale for Nursery Teachers (R-DLS-NT), a 15-item instrument adapted from the DigCompEdu framework and prior teacher digital competence research [6, 7]. Because DigCompEdu is a conceptual framework rather than a fixed questionnaire, the present study developed a nursery-context version tailored to teachers' digital practices in infant–toddler care settings. The scale comprised three dimensions: technological awareness (4 items), digital caregiving implementation (6 items), and data-driven evaluation ability (5 items). Items were rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating higher levels of digital literacy. Confirmatory factor analysis supported the three-factor structure of the scale, $\chi^2/df = 2.315$, CFI = .954, TLI = .926, RMSEA = .046. The internal consistency of the total scale was satisfactory (*Cronbach's* $\alpha = .92$).

AI-assisted observation self-efficacy: AI-assisted observation self-efficacy was measured using the AI-Assisted Observation Self-Efficacy Questionnaire for Nursery Teachers (AIOSE-NT), a 12-item scale adapted from recent work on teachers' AI competence self-efficacy [11]. Given that the original AI self-efficacy framework was developed primarily for instructional settings, the present study revised the scale to reflect nursery teachers' use of AI-supported observation tools in caregiving contexts. The adapted scale included four dimensions: AI tool operation efficacy (3 items), observation interpretation efficacy (3 items), caregiving decision support efficacy (3 items),

and ethical and human-centered use efficacy (3 items). Sample items included "I am confident that I can use AI-supported observation tools to better understand children's daily behavior patterns" and "I can appropriately interpret AI-generated observation feedback when planning responsive caregiving." Responses were recorded on a 7-point Likert scale, with higher scores indicating stronger efficacy beliefs. Confirmatory factor analysis supported the four-factor structure of the scale, $\chi^2/df = 1.864$, CFI = .921, TLI = .932, RMSEA = .036. The scale demonstrated good internal consistency (*Cronbach's* $\alpha = .86$).

Responsive caregiving quality: Responsive caregiving quality was assessed using the Responsive Caregiving Quality Self-Report Scale Derived from CLASS Infant/Toddler (RCQ-SR), a 12-item self-report measure adapted from the CLASS Infant and CLASS Toddler frameworks [9, 10]. Because CLASS is an observational assessment system rather than a self-administered questionnaire, the present study developed a self-report version based on the core dimensions of infant–toddler interaction quality that were most relevant to responsive caregiving. The scale comprised four dimensions: relational and emotional support (3 items), sensitivity and contingent response (3 items), support for exploration and learning (3 items), and language and interactional stimulation (3 items). Sample items included "I quickly notice when a child needs comfort or adjustment in care routines" and "I adjust my caregiving responses according to each child's signals and developmental level." Responses were given on a 5-point Likert scale, with higher scores indicating higher perceived responsive caregiving quality. Confirmatory factor analysis supported the four-factor structure of the scale, $\chi^2/df = 1.742$, CFI = .954, TLI = .926, RMSEA = .046. The total scale showed satisfactory internal consistency (*Cronbach's* $\alpha = .92$).

2.3 Procedure

After institutional permission had been obtained, participants completed anonymous questionnaires either online or in paper-and-pencil form during scheduled professional development sessions. Before participation, teachers were informed that participation was voluntary and anonymous and that the data would be used for research purposes only. Completing the questionnaire was treated as informed consent. To reduce evaluation concerns, participants were assured that no individual responses would be reported back to administrators.

2.4 Data Analysis

Data were analyzed using SPSS 26.0 and Mplus 8.3. Preliminary analyses included data screening, descriptive statistics, internal consistency estimation, and Pearson correlation analyses. To examine whether common method bias constituted a serious threat, a Harman single-factor test was conducted through confirmatory factor analysis by comparing the fit of a one-factor model with commonly accepted thresholds for model adequacy.

To test the mediation hypothesis, Hayes' PROCESS macro (Model 4) was used. Digital literacy was entered as the independent variable, AI-assisted observation self-

efficacy as the mediator, and responsive caregiving quality as the dependent variable. Age and years of teaching experience were included as covariates. Bootstrap procedures with 5,000 resamples were used to estimate bias-corrected 95% confidence intervals for indirect effects. An indirect effect was considered significant if the confidence interval did not include zero.

3 Results

3.1 Common Method Bias Test

Because all variables were assessed through self-report questionnaires, we first examined whether common method bias constituted a serious threat to the findings. A Harman single-factor model was tested by loading all items from the three core measures onto one common latent factor. The one-factor model demonstrated poor fit to the data, $\chi^2(702) = 5265.34$, $p < .001$, RMSEA = .138, CFI = .58, TLI = .55, SRMR = .124, indicating that a single common source factor could not adequately explain the covariance among the items. Therefore, common method bias was unlikely to seriously distort the main findings.

3.2 Descriptive Statistics and Correlations

Table 1 presents the descriptive statistics and correlations among the study variables. Digital literacy was significantly and positively correlated with AI-assisted observation self-efficacy ($r = .653$, $p < .01$) and responsive caregiving quality ($r = .485$, $p < .01$). AI-assisted observation self-efficacy was also positively associated with responsive caregiving quality ($r = .463$, $p < .01$). In addition, age was negatively related to digital literacy ($r = -.122$, $p < .05$) but positively related to responsive caregiving quality ($r = .142$, $p < .01$), whereas years of teaching experience showed small and nonsignificant associations with the focal constructs. Overall, the pattern of correlations was consistent with the hypothesized model and suggested that nursery teachers with stronger digital resources also tended to report stronger efficacy beliefs and higher-quality caregiving.

Table 1. Descriptive statistics and intercorrelations among the main study variables ($N = 346$)

Variable	1	2	3	4	5	*M*	*SD*
1. Age	1					32.452	6.823
2. Teaching experience	.821**	1				8.143	5.234
3. DL	-.122*	.082	1			3.528	1.101
4. AISE	-.041	.023	.653**	1		2.882	1.299
5. RC	.142**	.064	.485**	.463**	1	3.646	0.994

[a.] DL = digital literacy, AISE = AI-assisted observation self-efficacy, RC = responsive caregiving. *$p < .05$. **$p < .01$

3.3 Mediation Analysis

To test the hypothesized mediation model, Hayes' PROCESS Model 4 with 5,000 bootstrap resamples was estimated while controlling for age and years of teaching experience. All focal variables were standardized prior to analysis to facilitate interpretation of effect sizes.

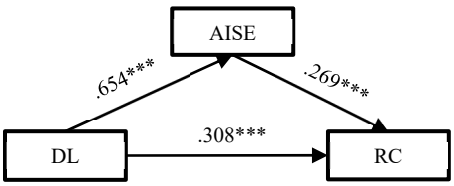
As shown in Table 2, digital literacy significantly and positively predicted AI-assisted observation self-efficacy ($\beta = .654$, $SE = .041$, $t = 16.012$, $p < .001$), explaining 43.0% of the variance in the mediator. When both digital literacy and AI-assisted observation self-efficacy were entered simultaneously to predict responsive caregiving quality, both variables remained significant. Digital literacy had a direct positive effect on responsive caregiving quality ($\beta = .308$, $SE = .060$, $t = 5.122$, $p < .001$), and AI-assisted observation self-efficacy also positively predicted responsive caregiving quality ($\beta = .269$, $SE = .060$, $t = 4.463$, $p < .001$). The outcome model explained 29.4% of the variance in responsive caregiving quality. The mediation pathway is presented visually in Figure 1.

Table 2. Mediation analysis of AI-assisted observation self-efficacy in the association between digital literacy and responsive caregiving quality

Path / Model	*β*	*SE*	*t*	*p*	95% CI	R^2
Mediator model						.430
DL → AISE	.654	.041	16.012	< .001	[.574, .734]	
Outcome model						.294
DL → RC (direct effect, *c'*)	.308	.060	5.122	< .001	[.190, .426]	
AISE → RC	.269	.060	4.463	< .001	[.151, .387]	
Total and indirect effects						
Total effect (*c*) of DL on RC	.484	.054	8.963	< .001	[.378, .590]	
Indirect effect (*ab*) via AISE	.176	.041	—	—	[.096, .259]	

[b.] DL = digital literacy, AISE = AI-assisted observation self-efficacy, RC = responsive caregiving.

Bootstrap analyses further showed that the indirect effect of digital literacy on responsive caregiving quality through AI-assisted observation self-efficacy was significant ($\beta_{ab} = .176$, $SE = .041$, 95% CI [.096, .259]). Because the direct effect remained significant after inclusion of the mediator, the mediation was partial. The indirect effect accounted for 36.4% of the total effect, indicating that AI-assisted observation self-efficacy explained a substantial portion, though not all, of the association between digital literacy and responsive caregiving quality. Taken together, these results supported H1, H2, and H3.



[c.] DL = digital literacy, AISE = AI-assisted observation self-efficacy, RC = responsive caregiving quality. ***$p < .001$; Standardized coefficients; controls: age, teaching experience.

Fig. 1. Mediation Model

4 Discussion

The present study examined whether nursery teachers' digital literacy is associated with responsive caregiving quality in information-rich childcare settings and whether AI-assisted observation self-efficacy mediates this association. Three main findings emerged. First, digital literacy was positively associated with responsive caregiving quality. Second, digital literacy was strongly related to AI-assisted observation self-efficacy. Third, AI-assisted observation self-efficacy partially mediated the relationship between digital literacy and responsive caregiving quality. Together, these findings suggest that digital competence in nursery contexts should be understood not simply as technical readiness, but as a professional resource that supports teachers' interpretation, judgment, and interaction in care work.

The positive association between digital literacy and responsive caregiving quality extends prior research in two important ways. Most previous studies on teacher digital competence have emphasized instructional innovation, technology integration, or the use of digital educational resources [2, 3, 6, 8]. The present findings indicate that in nursery settings, digital literacy may also matter for care-oriented outcomes. This is theoretically plausible because responsive caregiving in digitally enhanced environments increasingly depends on teachers' ability to access, evaluate, and act on information produced by documentation systems, behavior logs, or AI-supported observations. Teachers with stronger digital literacy may be better positioned to identify relevant cues, coordinate information across contexts, and tailor responses to children's immediate needs.

This finding is also consistent with ecological systems theory. In digitally mediated nursery environments, teachers' daily microsystems include not only child–teacher interaction but also engagement with platforms, records, and intelligent feedback systems. Digital literacy can therefore be viewed as a competence for functioning effectively within a transformed professional ecology. Rather than competing with relational care, competent use of digital information may strengthen teachers' ability to provide individualized, timely, and developmentally appropriate responses. In this sense, digital literacy supports responsive caregiving when it is embedded in child-centered professional judgment rather than treated as an end in itself.

The mediating role of AI-assisted observation self-efficacy is particularly important. In line with self-efficacy theory, the results suggest that technical competence may influence practice partly by shaping teachers' confidence in carrying out domain-specific tasks [13]. Nursery teachers with stronger digital literacy are likely to have more successful experiences with AI-supported tools, to feel less overwhelmed by platform interfaces and data outputs, and to perceive greater control when integrating digital information into observation. These experiences can strengthen efficacy beliefs, which in turn increase willingness to engage with AI-generated feedback, persistence when systems are imperfect, and confidence in transforming digital observations into responsive action.

The partial nature of the mediation is equally meaningful. It indicates that AI-assisted observation self-efficacy is an important but not exclusive pathway linking digital literacy to responsive caregiving quality. Other mechanisms may also matter,

such as reflective practice, perceived institutional support, technology acceptance, data-use routines, or collaborative learning among teachers. Digitally literate teachers may, for example, be more likely to participate in professional communities, seek resources, or communicate more effectively with colleagues and families through digital systems. These additional routes should be examined in future research to build a more comprehensive account of how digitalization shapes nursery care quality.

The study also contributes to the emerging literature on digitalization in early childhood settings. Current discussions increasingly emphasize that the educational value of digital technology depends on how adults use it, under what conditions, and toward what purposes [1–3, 14-15]. The present findings support this position by showing that digitalization is not merely a matter of introducing AI-supported tools into nursery settings. Technology becomes meaningful when teachers possess the competence and confidence needed to interpret digital outputs in relation to children's real-time needs. This point is especially important in infant–toddler care, where responsiveness requires sensitivity, contingency, and ethical judgment that cannot be outsourced to technology.

Several practical implications follow. First, digital transformation in nursery institutions should focus not only on infrastructure but also on workforce development. Training should help teachers build digital literacy in ways that are directly connected to observation, documentation, and responsive care. Second, professional development should explicitly target efficacy-building experiences. Hands-on practice, guided interpretation of AI-generated outputs, modeling, and supportive feedback may help teachers develop confidence in using digital observation systems effectively. Third, administrators and developers should pay attention to teacher-centered system design. AI tools that are opaque, difficult to interpret, or poorly aligned with caregiving routines may weaken rather than strengthen professional judgment. Finally, digitalization should be evaluated against its contribution to children's lived experiences. The ultimate goal is not technological sophistication itself, but stronger human responsiveness and better developmental support.

Several limitations should be acknowledged. First, the cross-sectional design limits causal inference. Although the proposed mediation model is theoretically grounded, longitudinal and intervention-based studies are needed to establish temporal ordering more convincingly. Second, all focal variables were assessed through self-report. Although the common method bias test did not indicate a serious threat, future research should combine survey data with direct observation, platform-use logs, or supervisor ratings. Third, the sample was drawn from nursery institutions that already used intelligent observation systems, which may limit generalizability to less digitalized settings. Fourth, the study focused on one mediator only. Future studies could test more complex models involving moderators such as institutional climate, leadership support, or ethical concerns regarding AI use.

Despite these limitations, the study offers empirical evidence for a mechanism that has been theoretically discussed but rarely tested in nursery care contexts. It shows that digital literacy is associated with responsive caregiving not only directly but also indirectly through teachers' confidence in using AI-supported observation. This helps clarify why some digitalization efforts may strengthen professional practice while others

remain superficial: technology is most likely to matter when teachers can use it competently, confidently, and in the service of children's needs.

5 Conclusion

This study showed that nursery teachers' digital literacy is positively associated with the quality of responsive caregiving in technology-enhanced childcare settings and that AI-assisted observation self-efficacy partially mediates this relationship. The findings indicate that digital literacy should be viewed as a professional competence that helps teachers transform digital information into sensitive, timely, and individualized caregiving responses. They also underscore that AI-supported nursery reform requires more than equipment deployment: it requires teachers who are both capable of using digital tools and confident in integrating AI-assisted observation into professional judgment. Strengthening these capacities may be an important pathway for improving the quality of responsive caregiving in digitally transforming nursery institutions.

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