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The relationship between parental digital self-efficacy, preschoolers' electronic media use, and learning quality—variable-centered and person-center analysis

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Background: Drawing on social cognitive theory, this study investigated how parental digital self-efficacy relates to preschoolers' learning quality and whether children's electronic media use helps explain this association.

Methods: Data were collected from 1,484 kindergarten children and their parents using the Parental Digital Self-Efficacy Scale, the Preschoolers' Learning Quality Questionnaire, and the Children's Electronic Media Use Questionnaire. We conducted both variable-centered analyses to test mediation pathways (positive vs. negative electronic media use) and person-centered analyses to identify parental digital self-efficacy profiles and compare their associations with children's learning quality.

Results: Variable-centered results showed that parental digital self-efficacy significantly enhanced children's learning quality primarily through promoting positive electronic media use, whereas negative use showed only a weak inhibitory effect; the positive-use pathway explained substantially more variance than the negative-use pathway. Person-centered analyses identified five parental digital self-efficacy profiles (information-limited, low-efficiency and lagging, information-coordinated, well-balanced versatile, and safety-pragmatic). Using the information-limited profile as the reference, the low-efficiency and lagging profile significantly and negatively predicted children's learning quality, whereas the well-balanced versatile profile significantly and positively predicted it; children's electronic media use partially mediated these profile-learning quality associations.

Conclusion: Parental digital self-efficacy appears to be a meaningful lever for improving preschoolers' learning quality, largely by fostering children's positive (rather than merely reducing negative) electronic media use; interventions may benefit from targeting specific parental self-efficacy profiles to promote developmentally supportive digital practices.

KEYWORDS
electronic media use, learning quality, parental digital self-efficacy, person-centered, variable-centered

1 Introduction

In the information age, electronic media have become deeply integrated into all aspects of social life and have gradually evolved into an indispensable part of young children's daily experiences and learning (Mann et al., 2025; Central Cyberspace Affairs Commission, 2021). Against this backdrop, national policies such as the National People's Congress of the PRC (2021) and the Office of the Central Cyberspace Affairs Commission (2021) underscore parents' primary responsibility in supporting their children's development. Parents' attitudes toward and patterns of electronic media use substantially shape the types, duration, and contexts of children's media engagement (Guo and Xue, 2000; Song et al., 2024; Zhang, 2023), which, in turn, influence the development of children's competencies in daily life and learning (Yuan et al., 2024). Social cognitive theory posits that individuals' beliefs and outcome expectancies jointly influence both behavioral choices and environmental regulation. Digital self-efficacy refers to one's judgment of their ability to use digital devices to accomplish specific tasks (Kim et al., 2021). For parents, digital self-efficacy represents not only a self-evaluation of operational competence with digital technologies but also expectations regarding the educational effectiveness of media-based parenting. These beliefs, in turn, inform their decisions about guidance and monitoring strategies in children's digital engagement.

Empirical studies have demonstrated that parents' digital self-efficacy shapes their digital-parenting attitudes and family mediation practices (Fidan and Olur, 2023). Such self-efficacy is associated with how parents manage children's screen time, the quality of content accessed, and the frequency of parent–child interactions (Mannell et al., 2024). Taken together, these factors may be associated with children's development, as the thoughtful use of digital resources can enhance preschoolers' learning quality (Gao, 2015). Dore et al. (2020) further found that when parents employ positive guidance strategies that align media use with educational goals, children's interest and attention in learning improve. Conversely, when parents fail to plan or regulate digital-device use effectively, children may participate less in real-world interactions, which may undermine learning development (Barr et al., 2010; Linebarger and Walker, 2005; Zhang and Xu, 2021).

2 Literature review

Learning quality serves as a key indicator of children's comprehensive learning competence, capturing learning-related tendencies such as curiosity, initiative, persistence, attention, reflection, imagination, and creativity (Vitiello et al., 2011; Wu et al., 2024; Zhang and Wang, 2025). Prior research suggests that parents' digital self-efficacy is associated with these learning qualities (Yusuf et al., 2020). For example, parents with higher self-efficacy are more likely to select high-quality digital resources, guide children toward meaningful media activities, and maintain positive engagement during use, which may support learning motivation, attention, and language development (Altindag Kumaş and Yildirim Sardohan, 2024; Lauricella et al., 2015; Neumann, 2016). However, other scholars have cautioned that high parental self-efficacy may, paradoxically, be associated with less appropriate supervisory behaviors (Livingstone et al., 2017). Overconfidence may reduce monitoring of screen time or content quality, potentially increasing children's exposure to prolonged or lower-quality screen environments (Madigan et al., 2019; Radesky et al., 2015; Cristóbal-Fransi et al., 2017; Geng et al., 2023). Therefore, this study proposes the following hypothesis:

H1: Parental digital self-efficacy is associated with preschoolers' learning quality; however, the direction of this relationship requires further empirical investigation.

Electronic media use refers to activities involving devices such as televisions, computers, tablets, or smartphones for entertainment, education, or social interaction (Merdin and Sahin, 2023). Preschoolers' electronic media use (EMU) reflects young children's behavioral tendencies during engagement with electronic media (Gao et al., 2023) and can be classified into positive and negative forms (Zara, 2020). Positive EMU typically involves adult-guided, interactive, or educationally oriented activities that support cognitive and social development (Nathanson, 2015). In contrast, negative EMU is characterized by passive, non-interactive viewing (e.g., prolonged solitary watching), which has been linked to attentional difficulties and poorer language and learning outcomes (World Health Organization, 2019).

Parental digital self-efficacy may be associated with the quality of children's EMU through distinct mechanisms. From a uses-and-gratifications perspective, parents with higher self-efficacy may proactively scaffold children's media engagement to serve educational motives, thereby promoting positive EMU and learning quality (Kabali et al., 2015). Conversely, social learning theory suggests that when parents use electronic media primarily as a "child-rearing tool" to soothe or distract children without sufficient supervision, children may develop maladaptive usage patterns (e.g., excessive exposure or limited interaction) that may undermine learning quality (Patton and Sawyer, 2000). By contrast, parents with lower digital self-efficacy may adopt a more cautious stance toward media and impose stricter control, which could also guide children toward more positive EMU (Kuldas et al., 2023). Given these competing pathways, this study examines the mediating role of children's EMU and proposes the following hypotheses:

H2: Parental digital self-efficacy is positively associated with preschoolers' learning quality through positive EMU.

H3: Parental digital self-efficacy is negatively associated with preschoolers' learning quality through negative EMU.

The PPCT model posits that development unfolds through dynamic interactions among Process–Person–Context–Time, with proximal processes serving as the engine of developmental change. Within preschool contexts, parents represent a key component of the child's microsystem. Their digital self-efficacy may shape children's daily electronic media engagement—the proximal process through which learning quality is associated with development. Children's behaviors during media use may, in turn, recalibrate parents' self-efficacy and the home media environment, producing a dynamic feedback loop. Guided by this framework, the present study examines both the direct association between parental digital self-efficacy and children's learning quality and the indirect association mediated by children's EMU.

Most existing research employs variable-centered approaches that emphasize mean relations among constructs, potentially overlooking individual-level heterogeneity within parent populations. Families differ in digital literacy, safety awareness, and parent–child communication, which may lead to distinct strategies for guiding children's media use and diverse implications for learning outcomes (Izrael et al., 2020; Sundqvist et al., 2021). To capture this heterogeneity, we apply latent profile analysis (LPA) to identify subgroups of parents with similar patterns of digital self-efficacy across multiple indicators. Compared with variable-centered methods, LPA can better delineate subgroup differences in competencies and support strategies, thereby clarifying pathways linking parental profiles to children's learning outcomes and informing targeted interventions. Based on the LPA-identified profiles, we propose and test the following hypotheses:

H4. Parental latent profiles of digital self-efficacy predict preschoolers' learning quality.

H5. The quality of children's electronic media use (EMU) mediates the relationship between parental latent profiles and learning quality; mediation pathways differ among parental profiles.

3 Methods

3.1 Participants

Using a convenience sampling method, we recruited preschool children and their parents from eight kindergartens in Provinces L and Y. A total of 1,674 questionnaires were distributed. Prior to analysis, we conducted data screening in SPSS 27.0. Questionnaires were excluded if (a) more than 20% of items were missing or any key scale (parental digital self-efficacy, electronic media use, or learning quality) was missing (n = 102); or (b) they showed implausible response patterns, including straight-lining across >90% of items or an extremely short completion time (<120 s) (n = 88). After exclusions (total n = 190), 1,484 valid responses were retained, yielding an effective response rate of 88.6%. The sample included 782 boys (52.7%) and 702 girls (47.3%).

Because participants were recruited from eight kindergartens in only two provinces using convenience sampling, the sample may not be fully representative of families in other regions or kindergarten settings (e.g., urban–rural differences, socioeconomic composition, and local digital-learning environments). Accordingly, the generalizability of the findings should be interpreted with caution.

Children's ages ranged from 2 to 7 years, with those aged 3–6 constituting the majority (97.0%): age 3, 12.5% (n = 186); age 4, 29.7% (n = 441); age 5, 29.9% (n = 443); and age 6, 24.9% (n = 369). Children aged 2 and 7 accounted for 1.0% (n = 15) and 2.0% (n = 30), respectively.

Regarding the parent–child relationship among respondents, mothers comprised 81.9%, fathers 13.0%, other guardians 4.6%, and grandparents 0.4%, indicating that mothers were the primary respondents, whereas fathers and other caregivers were less represented.

3.2 Measures

3.2.1 Parental digital self-efficacy

We used the Digital Self-Efficacy Scale originally developed by Ulfert-Blank and Schmidt (2022). The instrument comprises 25 items across five dimensions: Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Security, and Problem Solving. Items were rated on a 5-point Likert scale (0 = strongly disagree, 5 = strongly agree). Higher total scores indicate higher levels of digital self-efficacy.

In the present study, internal consistency was excellent for the total scale (α = 0.98) and good to excellent for the subscales (α = 0.75–0.95). Confirmatory factor analysis supported the five-factor structure, χ^2/df = 2.69, CFI = 0.95, TLI = 0.94, RMSEA = 0.04 [90% CI (0.038, 0.051)], and SRMR = 0.06, indicating good model fit and satisfactory construct validity.

3.2.2 Learning quality

Preschoolers' learning quality (LQ) were assessed with the Parent-Report Learning Quality Scale developed by Cai (2015), consisting of 41 parent-report items spanning five dimensions: Curiosity/Interest, Initiative, Persistence/Attention, Imagination/Creativity, and Reflection/Explanation. Each item is rated on a 4-point scale from 1 (never) to 4 (always). This multidimensional framework provides a comprehensive portrait of LQ.

In this study, reliability was excellent for the total scale (α = 0.98) and for subscales (α = 0.89–0.94). The five-factor model demonstrated acceptable fit, χ^2/df = 5.66, CFI = 0.86, TLI = 0.85, RMSEA = 0.08 [90% CI (0.07, 0.08)], SRMR = 0.05, supporting construct validity.

3.2.3 Preschoolers' electronic media use

Children's electronic media use (EMU) was assessed using the Quality of Electronic Media Use Questionnaire for Preschoolers (Ma, 2023), containing 28 items rated on a 5-point Likert scale (1 = never to 5 = always). The questionnaire comprises two dimensions: Positive Use (co-engagement, effective learning) and Negative Use (problematic use/addiction-like tendencies, passive screen exposure, independent use). Higher scores on the positive dimension indicate more constructive interaction and learning, whereas higher scores on the negative dimension reflect greater dependence and adverse effects.

In the current sample, internal consistency was high for the total scale (α = 0.92) and for the subscales (α = 0.81–0.96). A two-factor model showed acceptable fit, χ^2/df = 5.93, CFI = 0.96, TLI = 0.95, RMSEA = 0.08 [90% CI (0.07, 0.08)], and SRMR = 0.04, indicating good construct validity.

3.3 Data collection and analysis

All data were collected via an online questionnaire collection platform. We adopted both variable-centered and person-centered analytical approaches. First, data cleaning, descriptive statistics, and correlation analyses were conducted in SPSS 27.0.

Informed consent was obtained through the survey distribution process: the consent statement was sent together with the questionnaire, and participants indicated agreement before responding. Completed questionnaires were collected on the following day. During data screening, extreme values were identified using the ±3 SD criterion for primary continuous variables. Observations outside the mean ± 3 SD range were excluded from subsequent analyses.

In the variable-centered analyses, parental digital self-efficacy was entered as a continuous predictor in Model 4. For the person-centered analyses, we performed latent profile analysis (LPA) on the five parental digital self-efficacy (PDSE) dimension (subscale) scores in Mplus 8.3 (Muthén & Muthén, Los Angeles, CA, United States) to characterize both qualitative and quantitative heterogeneity within the parental sample (cf. Chiu, 2008). Specifically, mean scores for the five PDSE dimensions—communication and collaboration, digital content creation, security, problem solving, and information and data literacy—were computed from the corresponding items and entered as the classification indicators. After determining the optimal number of profiles (K), we exported the most-likely class variable (class) and entered it as a categorical independent variable in Mplus 8.3 to estimate mediation effects.

4 Results

4.1 Common method bias

Because data were collected through self-reported questionnaires from parents, we examined the potential for common method bias. Following Harman's single-factor criterion (Podsakoff et al., 2003), if the first factor accounts for less than 40% of the variance, a serious common method bias is unlikely. In the present study, the exploratory factor analysis identified 11 factors with eigenvalues greater than 1; the first factor explained 35.05% of the variance (< 40% threshold), indicating no substantial common method bias.

4.2 Descriptive statistics and correlations

As shown in Table 1, bivariate correlations indicated that parental digital self-efficacy, preschoolers' learning quality, and electronic media use were all positively intercorrelated (r = 0.15–0.60). Child age was negatively correlated with parental digital self-efficacy and negative media use (r = 0.06–0.08), but positively correlated with learning quality and positive media use (r = 0.08–0.11). Correlations with gender and relation were generally nonsignificant across variables. These results suggest close associations among the focal constructs and provide empirical support for subsequent path analyses.

4.3 Relationships among parental digital self-efficacy, preschoolers' learning quality, and electronic media use: variable-centered analysis

To further examine the mechanism by which parental digital self-efficacy (PDSE) influences preschoolers' learning quality (LQ), we specified a parallel mediation model with gende, relation and age as controls, PDSE as the independent variable, LQ as the dependent variable, and preschoolers' electronic media use (EMU) as mediators (separately modeled as positive EMU and negative EMU). Simple mediation analyses were conducted using the PROCESS macro for SPSS 27.0 (Model 4) with 5,000 bootstrap samples.

As shown in Table 2 and Figure 1, the mediation test indicated a total standardized effect of PDSE on LQ of β = 0.53 [95% CI (0.49,0.57)]. The direct effect was significant [β = 0.28, 95% CI (0.23, 0.33)], accounting for 52.79% of the total effect, thereby supporting H1 and suggesting a promotive effect independent of the mediators. The indirect effect operated through two independent paths: positive EMU [β = 0.26, 95% CI (0.22, 0.31); 49.80% of the total] and negative EMU [β = −0.01, 95% CI (−0.02, −0.01); 2.59% of the total]. The total indirect effect wasβ = 0.25 [95% CI (0.21, 0.29)], accounting for 47.21% of the total effect, thereby supporting H2.

Overall, PDSE significantly enhances LQ primarily by increasing positive EMU, whereas negative EMU exerts only a weak suppressor influence; the explanatory power of the positive-use pathway was substantially greater than that of the negative-use pathway. These findings provide theory-informed support for tiered intervention strategies in family digital education aimed at optimizing children's media use.

4.4 Latent classes of parental digital self-efficacy and their predictive effects on preschoolers' learning quality: a person-centered analysis

4.4.1 Latent classes of parental digital self-efficacy

To examine heterogeneity in parental digital self-efficacy (PDSE) and its association with preschoolers' learning quality, we conducted latent profile analysis (LPA). The five PDSE dimensions—Communication and collaboration, digital content creation, security, problem solving, information, and data literacy—were used as classification indicators, and models were estimated in Mplus 8.3 on the full sample (N = 1,484). Following recommended model-selection principles (e.g., Yin et al., 2020), we systematically compared 2- through 6-class solutions.

TABLE 1 Descriptive statistics and correlations ($N = 1,484$).

Variable	M + SD	1	2	3	4	5	6
1. Gender[a]	–	–	–	–	–	–	–
2. Relation	0.18 ± 0.38	0.01	–	–			
3. Age	4.71 ± 1.07	0.05	0.02	–	–	–	–
4. PDSE	92.89 ± 23.71	−0.01	0.03	0.08**	–	–	–
5. LQ	123.18 ± 24.50	0.03	−0.01	0.11**	0.54**	–	–
6. Positive EMU	25.56 ± 6.07	−0.03	0.02	0.08**	0.60**	0.60**	–
7. Negative EMU	34.57 ± 13.13	−0.02	0.101**	0.06*	0.21**	0.15**	0.35**

[a]Gender dummy coded; 0 = boy, 1 = girl.
*$p < 0.05$. **$p < 0.01$.

TABLE 2 Path analysis of the mediation model (standardized effects).

Effect	Path	β	Bootstrap CI	% of total
Direct	PDSE → LQ	0.28	(0.23, 0.33)	52.79
Indirect	PDSE → positive EMU → LQ	0.26	(0.22, 0.31)	49.8
	PDSE → negative EMU → LQ	−0.01	(−0.02, −0.01)	2.59[b]
Total indirect	—	0.25	(0.2101, 0.29)	47.21
Total	—	0.53	(0.49, 0.57)	100

[b]Negative % indicates the path runs opposite to the overall effect (absolute value reported).

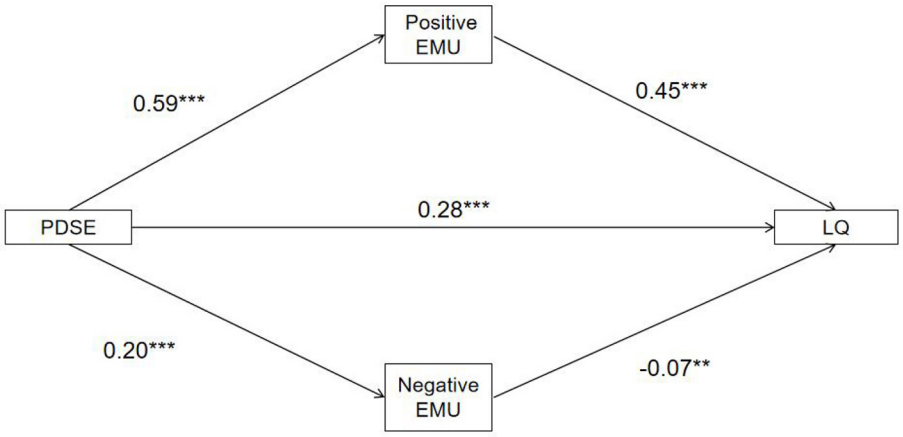

FIGURE 1
Relation, Gender, and age controlled; standardized paths shown. Depicts the model. **$p < 0.01$, ***$p < 0.001$.

Using Mplus 8.3, we estimated models with two to six latent classes and compared model fit across solutions (see Table 3). Model evaluation was primarily based on AIC, BIC, aBIC, and the bootstrap likelihood ratio test (BLRT). Consistent with prior guidance, lower AIC/BIC/aBIC values combined with a BLRT p <0.001 indicate superior fit. In our analyses, these information criteria improved monotonically as the number of classes increased. Moreover, the 5-class solution introduced additional complexity by splitting the sample into smaller subgroups (e.g., classes with proportions around 0.06 and 0.09), which reduced parsimony and did not yield clearly distinct, theoretically meaningful profiles beyond those captured in the 4-class model. Considering overall model fit, classification quality, parsimony, and substantive interpretability, we therefore selected the 4-class model as the final solution. As shown in Table 3, the class proportions for the 4-class solution were 0.07, 0.33, 0.27, and 0.33. Classification quality was acceptable, as indicated by entropy = 0.90 and high average posterior class-membership probabilities for the four classes (0.96, 0.95, 0.96, and 0.91).

Based on further analysis of the data in Figure 2, the four latent profiles of parental digital self-efficacy were labeled as follows:(1) C1: Low-efficiency and lagging profile (Scores on all five dimensions were markedly below the mean, with the lowest levels observed in communication and collaboration and security, and similarly large deficits in information and data literacy; digital content creation and problem solving were

also substantially below the mean.); (2) C2: Moderately high profile (Scores were slightly above the mean across all five dimensions, indicating a modest and relatively balanced advantage. Communication and collaboration, security, and information and data literacy were comparatively higher, whereas digital content creation and problem solving showed smaller increases, reflecting a mild upward pattern overall.); (3) C3: Moderately low profile (Scores were below the mean across all five dimensions, but the magnitude of deviation was moderate and clearly smaller than that observed in the low-efficiency and lagging profile. The pattern was consistently low across dimensions, with information and data literacy being relatively less negative than the other domains.); (4) C4: High-efficiency and all-round profile (Scores on all five dimensions were clearly above the mean. The most salient elevations were observed in digital content creation and problem solving, followed by security and communication and collaboration, whereas information and data literacy was comparatively lower but remained above the mean).

4.4.2 Group differences in electronic media use and learning quality

The analysis indicated that analysis of variance (ANOVA) revealed significant differences among the five profiles in preschoolers' electronic media use and learning quality (see Table 4).

4.4.3 Effects of different latent classes on preschoolers' learning quality

To examine whether parental digital self-efficacy latent class membership was associated with preschoolers' learning quality (LQ), children's gender and age were entered as covariates. Latent class membership (C1–C4) was dummy-coded and treated as a multicategorical independent variable (reference group: Low-efficiency and lagging, C1). Following Asparouhov and Muthén (2014), we conducted relative mediation analyses using the Mplus 8.3 software using the BCH approach. Electronic media use (EMU) was evaluated as the mediator and LQ as the outcome (Table 5).

These findings suggest that, compared with the Low-efficiency and lagging, the C2–C4 profiles were associated with higher preschoolers' learning quality, supporting H4.

To clarify the mechanisms underlying these between-class differences, EMU was examined as two distinct mediators in separate models: positive use (M1) and negative use (M2).

4.4.3.1 Mediation via positive EMU (M1)

As shown in Table 5, the indirect effect via positive EMU was statistically significant for all three contrasts. Specifically, the bootstrapped indirect effects were 1.19 for C2 vs. C1 [SE = 0.13, 95% CI (0.95, 1.44)], 0.72 for C3 vs. C1 [SE = 0.13, 95% CI (0.47, 0.97)], and 1.75 for C4 vs. C1 [SE = 0.13, 95% CI (1.50, 2.01)]. These mediated pathways accounted for the majority of the relative effect quantity (88.1%, 97.3%, and 92.6%, respectively; Table 5). Consistent with Figure 3, class contrasts were associated with greater positive EMU (e.g., 0.70 for C3 vs. C1 and 1.80 for C4 vs. C1), and positive EMU was positively associated with LQ (0.47), indicating that positive media engagement represents the primary pathway linking higher digital self-efficacy profiles to better learning quality.

4.4.3.2 Mediation via negative EMU (M2)

In contrast, the indirect pathway through negative EMU was comparatively small. Figure 4 indicates that class contrasts were associated with higher negative EMU (0.28 for C2/C3 vs. C1 and 0.68 for C4 vs. C1), and negative EMU was negatively associated with LQ (−0.07), implying a countervailing indirect pathway. In Table 5, the proportion of the relative effect quantity attributed to M2 was small (e.g., 2.2% for C2 vs. C1 and 4.2% for C4 vs. C1), and the C3 vs. C1 indirect effect via M2 was not reliably different from zero. Thus, negative EMU appears to serve as a minor suppressing mechanism that may slightly attenuate the positive association between class membership and learning quality, but it does not account for the dominant between-class differences.

5 Discussion

5.1 Effects of parental digital self-efficacy on preschoolers' learning quality

Our findings indicate that parental digital self-efficacy is significantly associated with preschoolers' learning quality. Parents with higher digital self-efficacy are more likely to curate and scaffold children's use of digital resources and to integrate digital experiences with offline learning opportunities, which may support deeper understanding and sustained engagement (Livingstone and Blum-Ross, 2020; Marsh et al., 2017; Neumann and Neumann, 2017).

In addition, higher digital self-efficacy may promote persistence and adaptive problem-solving when technical challenges arise, reducing disruptions to learning-oriented media use (Schunk and DiBenedetto, 2020). Conversely, lower self-efficacy may be linked to avoidance or anxiety around digital tools, limiting the extent to which families can translate digital access into educational benefits (Plowman et al., 2010).

Overall, parental digital self-efficacy may reflect both technological confidence and pedagogical adaptability in digital contexts, helping explain individual differences in preschoolers' learning quality.

5.2 Parental digital self-efficacy and preschoolers' learning quality: the mediating role of electronic media use

The present study shows that parental digital self-efficacy is positively associated with preschoolers' learning quality, highlighting the role of parents' perceived capability in shaping children's learning-related digital experiences. Parents with higher digital self-efficacy may be more likely to provide effective media guidance—such as supporting purposeful use, setting clear

TABLE 3 Fit indices for 2–6 class LPA models.

Classes	AIC	BIC	aBIC	BLRT *p*	Entropy	Class probabilities	Posterior probabilities
2	40,918.27	41,003.11	40,952.28	0	0.89	0.47/0.53	—
3	39,391.23	39,507.88	39,438.99	0	0.91	0.09/0.46/0.45	—
4	38,469.99	38,608.47	38,519.52	0	0.90	0.07/0.33/0.27/0.33	0.96/0.95/0.96/0.91
5	37,989.74	38,170.02	38,062.01	0	0.90	0.04/0.10/0.33/0.26/0.27	—
6	37,648.35	37,860.45	37,733.38	0	0.90	0.03/0.09/0.09/0.24/0.26/0.29	—

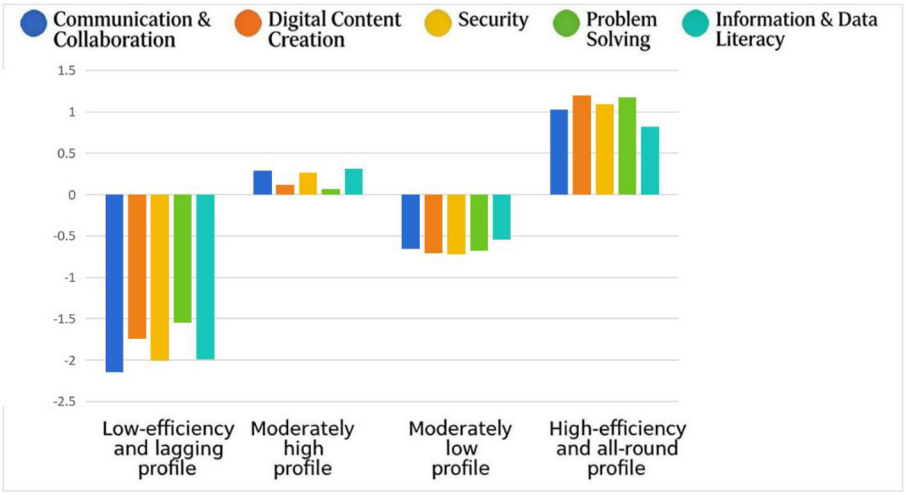

FIGURE 2
Potential categories of parental digital self-efficacy.

TABLE 4 Differences across PDSE profiles (C1–C4).

Variable		C1	C2	C3	C4	*F*	*Post hoc*
Positive EMU	Shared communication	11.64	16.19	14.3	18.34	186.572**	C1 < C3 < C2 < C4
	Effective learning	7.48	10.02	9.2	11.89	114.054***	C1 < C3 < C2 < C4
Negative EMU	Problematic use	11.9	13.51	13.59	15.88	24.613***	C1 < C2/C3 < C4
	Screen exposure	9.22	10.6	10.29	11.76	14.083***	C1 < C2/C3 < C4
	Independent use	8.54	9.55	9.59	11.5	22.769**	C1 < C2/C3 < C4
Learning quality	Curiosity/interest	9.95	21.38	26.07	24.52	107.789***	C1 < C2 < C4 < C3
	Initiative	25.66	20.42	26.36	23.98	164.433***	C2 < C4 < < C1 < C3
	Persistence/attention	22.1563	26.6545	24.748	29.5237	131.477***	C1 < C3 < C2 < C4
	imagination and creativity	21.48	27.66	25.16	31.57	158.057**	C1 < C3 < C2 < C4
	Reflection/explanation	14.51	18.47	17.06	20.9	135.988**	C1 < C3 < C2 < C4

$^{**}p < 0.01$, $^{***}p < 0.001$.

expectations, and engaging in collaborative parent–child learning—which is linked to greater learning initiative and engagement in children (Coyne et al., 2023).

In families where parental digital self-efficacy is lower, children may receive less timely technical and informational support and may therefore turn to peers or self-directed sources for guidance on internet use (Kenny et al., 2015). Such patterns can reduce parent–child communication about online experiences and, in turn, weaken opportunities for constructive monitoring and scaffolding in the digital context.

Notably, the mediating role of children's media-use quality was differentiated: the promotive pathway via positive use was substantially stronger than the suppressive pathway via negative use. This asymmetry suggests that developmental implications depend more on how children engage with media than on media exposure per se, and that digitally efficacious parenting

TABLE 5 Relative mediation (profiles vs. information-only; standardized).

Contrast		Relative direct effect			Relative indirect effect			Relative effect quantity
		β	SE	Bootstrap CI	Mediation effect	SE	Bootstrap CI	
C2 vs. C1	M1	0.16	0.06	(0.03, 0.29)	1.19	0.13	(0.95, 1.44)	88.1%
	M2	1.32	0.15	(1.03, 1.61)	−0.03	0.02	(0.004, 0.062)	2.2%
C3 vs. C1	M1	0.02	0.06	(−0.11, 0.14)	0.72	0.13	(0.47, 0.97)	97.3%
	M2	0.71	0.15	(0.41, 0.99)	−0.03	0.01	(−0.001, 0.051)	–
C4 vs. C1	M1	0.14	0.08	(−0.13, 0.29)	1.75	0.13	(1.50, 2.01)	92.6%
	M2	1.81	0.15	(1.52, 2.11)	−0.80	0.02	(0.04, 0.12)	4.2%

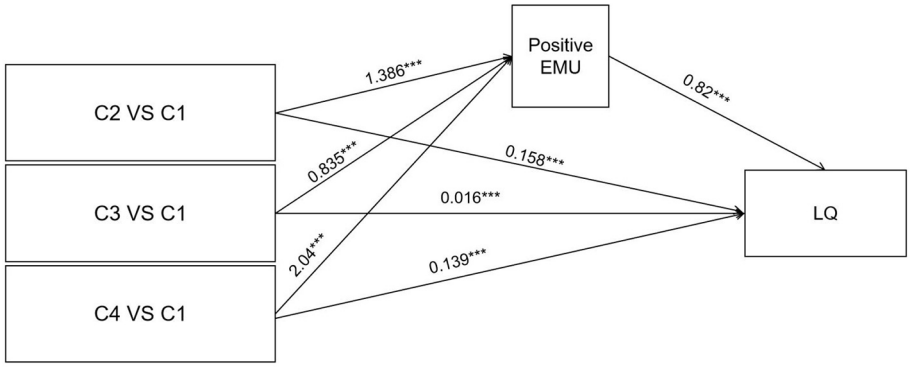

FIGURE 3
Mediation model 1-positive use from an individual-centered perspective. ***$p < 0.001$.

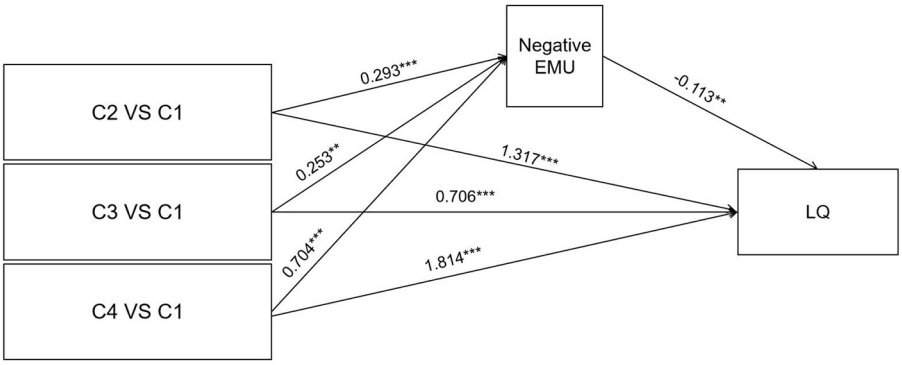

FIGURE 4
Mediation model 2: negative use from an individual-centered perspective. **$p < 0.01$, ***$p < 0.001$.

may be especially relevant for fostering constructive forms of engagement.

These findings are consistent with social cognitive theory's triadic reciprocal determinism. Higher parental digital self-efficacy may support the creation of a more supportive media environment (e.g., curating age-appropriate resources and setting structure), which is associated with more adaptive child media behaviors and higher learning quality. Children's adaptive engagement may, in turn, reinforce parents' confidence and continued involvement, sustaining a positive feedback loop over time.

5.3 Effects of different parental digital self-efficacy classes on preschoolers' learning quality: the mediating role of electronic media use

Within a person-centered framework, we used latent profile analysis (LPA) to identify five parental profiles: Information-Only, Low-Efficiency/Lagging, Information-Coordinated, All-Round/Balanced, and Safety-Pragmatic. Subsequent mediation

analyses indicated that these profiles differed in how children's electronic media use (EMU) was associated with learning quality (LQ).

Using the Information-Only profile as the reference group, parents in the Low-Efficiency/Lagging profile showed comparatively low digital competence across dimensions. Their lower levels of children's learning quality were primarily associated with reduced positive EMU, whereas the pathway via changes in negative EMU was comparatively weak. This pattern may reflect limited confidence and strategies for addressing routine technical demands and for sustaining digital co-engagement, which can constrain parents' ability to scaffold children's constructive media use.

In contrast, the All-Round/Balanced profile demonstrated consistently high competence across information literacy, communication/collaboration, safety awareness, and problem solving. For this profile, the association with higher learning quality was largely accounted for by enhanced positive EMU, suggesting that balanced competencies may support a more structured and resource-rich home digital learning ecology (e.g., purposeful co-use and guided exploration). From an ecological integration perspective, coordinated resources across multiple domains of the home environment may strengthen the stability and inclusiveness of learning supports, making positive EMU more likely to translate into learning benefits.

Finally, person-centered and variable-centered approaches yielded both convergence and added nuance. Both approaches showed that the facilitative role of positive EMU outweighed the suppressive role of negative EMU. However, the person-centered results highlighted heterogeneity across profiles—for example, the Low-Efficiency/Lagging profile showed little evidence of a positive-use pathway, whereas the All-Round/Balanced profile showed only a minimal negative-use pathway. Practically, these findings suggest tailoring interventions: strengthening constructive guidance skills for Low-Efficiency/Lagging parents, while offering balance-oriented strategies for higher-competency profiles to prevent drift toward overuse.

6 Educational implications

6.1 Provide digital-literacy training to enhance parental digital self-efficacy

Efforts to strengthen parental digital self-efficacy should be differentiated by parent type. For Information-Only parents, broaden access to digital resources and diversify content to enrich parenting practices. Low-Efficiency/Lagging parents can begin with basic device operations and common software to gradually reduce technological barriers. Information-Coordinated parents may build on their strengths in information processing and communication by emphasizing online safety and creative applications. All-Round/Balanced parents should maintain multidimensional competencies while pacing media use appropriately. Safety-Pragmatic parents, while prioritizing safety, could increase interactive and creative activities. Such tiered guidance not only enhances parents' digital literacy but also helps them use digital resources more effectively in daily life to support children's development.

6.2 Develop evidence-informed media plans to guide positive use

To optimize preschoolers' electronic media use, parents should develop age- and interest-appropriate media plans that specify daily or weekly duration and prioritize content, thereby preventing purposeless, prolonged passive use. Select educational, exploratory, and creative resources, and incorporate parent–child interaction (e.g., co-viewing followed by discussion or extending content into real-world activities). For families prone to negative media use, preparing a curated list of high-quality options ensures that children choose within appropriate boundaries. By combining structured planning, high-quality resources, and active interaction, parents can significantly enhance the educational value of children's media experiences.

6.3 Integrate digital and real-world contexts to sustain gains in learning quality

To foster learning quality, parents and teachers should jointly create a supportive learning environment that integrates digital experiences with everyday contexts. For instance, after watching a science-experiment video, children can replicate the experiment hands-on, or express newly learned knowledge through drawing, storytelling, or performance—consolidating understanding while stimulating creativity. In daily routines, breaking larger tasks into manageable sub-goals and pairing them with timely feedback and encouragement can strengthen focus and persistence. Home–school collaboration is essential: teachers can extend classroom themes and learning activities into home settings, enabling children to practice and apply knowledge across contexts and thereby sustain continuous, multidimensional growth in learning quality.

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8 Significance and limitations

This study integrates variable-centered and person-centered approaches to elucidate both the mechanisms and subgroup heterogeneity underlying the relationship between parental digital self-efficacy and preschoolers' learning quality. The findings extend traditional self-efficacy theory into the context of digital parenting and provide practical insights for family education. By identifying distinct parental profiles of digital self-efficacy, the study offers a foundation for targeted interventions that optimize the home digital environment, strengthen parents' digital-parenting competencies, and, in turn, promote children's comprehensive development in learning quality. Furthermore, by emphasizing the quality of children's electronic media use and its mediating function, the study contributes theoretical support for evidence-based guidance on children's media use.

The study has several limitations. First, the use of convenience sampling may limit sample representativeness. Future research should broaden the sampling scope to improve diversity and generalizability. Second, the respondent pool was predominantly mothers (approximately 82%), with fathers and other caregivers underrepresented; therefore, generalizability across caregiver types should be interpreted with caution, and future studies should recruit more balanced caregiver samples. Third, as all data were based on parent self-reports, subjective bias cannot be ruled out. Future studies could adopt multi-informant and multi-method designs (e.g., teacher assessments, behavioral observations) to more comprehensively evaluate both children's learning quality and parents' digital self-efficacy.

In addition, because the sample was drawn from eight kindergartens in two provinces, regional and institutional characteristics may have influenced parents' digital experiences and children's media-use opportunities; replication in more diverse regions and settings is warranted.

9 Conclusion

Drawing on both variable-centered and person-centered perspectives, this study explored the mechanisms and subgroup variations linking parental digital self-efficacy to preschoolers' learning quality. The main findings are as follows:

(1) Parental digital self-efficacy significantly associate with children's learning quality, with children's electronic media use serving as a partial mediator.
(2) Parents can be categorized into four latent profiles based on their digital self-efficacy: Low-efficiency and lagging profile, Moderately high profile, Moderately low profile, High-efficiency and all-round profile.
(3) These profiles exert distinct effects on children's learning quality: compared with the Low-efficiency and lagging profile, the Moderately high profile, Moderately low profile, and High-efficiency and all-round profile are all positively associated with learning quality, with the strongest positive association observed for the High-efficiency and all-round profile. These differences are partially explained by electronic media use, primarily through increased positive use, whereas negative use provides a small countervailing pathway, especially for the High-efficiency and all-round profile.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Review Committee of Liaoning Normal University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

HC: Conceptualization, Writing – original draft, Writing – review & editing, Project administration, Supervision, Validation, Funding acquisition. WQ: Investigation, Writing – review & editing, Conceptualization, Methodology, Software, Visualization, Writing – original draft. YZ: Writing – review & editing, Data curation, Investigation.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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