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Problematic media use, loneliness, and digital literacy in primary school children

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Abstract

This study aims to examine the relationship between problematic media use (PMU), digital literacy (DL), and loneliness among primary school children. The participants were 957 children aged 8 to 11 years. Data were collected using standardized instruments measuring PMU, loneliness, and DL, and analyzed using GLM analysis. The findings revealed significant relationships between DL, loneliness, and PMU. Loneliness was statistically associated with PMU both directly and indirectly, with DL accounting for part of this association. The findings suggest that loneliness is meaningfully related to higher levels of PMU. Higher levels of DL do not necessarily ensure healthy media habits, particularly among children experiencing loneliness. Therefore, DL education should move beyond technical skills to include components that foster emotional regulation and social connection. In this regard, DL programs should be designed to address not only cognitive but also emotional and social needs.

Keywords Primary school children · Problematic media use · Loneliness · Digital literacy

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1 Introduction

In recent decades, digital technologies have become deeply embedded in everyday life, reshaping key domains such as communication, business, finance, healthcare, and education (Cowling et al., 2025; Martin, 2006; Zaťková et al., 2024). While access to computers was limited in the 1980s, rapid technological advancements have since enabled a wide range of online learning and assessment practices. Today's children increasingly benefit from these developments, gaining expanded opportunities to communicate, access, and evaluate information, make informed health-related decisions, and interact with diverse educational content (Meates, 2020; Purnama et al., 2021; Taşkın & Ok, 2022; Tuan et al., 2024). Despite the many benefits of digital tools, their potential adverse effects have also been widely discussed in the literature. Researchers have noted that excessive use of digital devices among young children may lead to several negative consequences (Hosokawa & Katsura, 2018; Yao & Zhong, 2014). These include exposure to violent content through games and videos, excessive screen time, and a lack of social interaction—all of which may negatively affect children's development (Hosokawa & Katsura, 2018). Notably, excessive exposure to the internet and digital media is known to increase the risk of developing addictive behaviors. Among children with such tendencies, feelings of loneliness are reported to be higher (Yao & Zhong, 2014). Studies have provided compelling evidence regarding the link between internet addiction and loneliness (Marttilla et al., 2021; O'Day & Heimberg, 2021).

To address the potential risks associated with digital media, several studies have emphasized the importance of fostering digital resilience in children (Putra & Irwansyah, 2024; Vissenberg et al., 2022). For instance, Putra and Irwansyah (2024) highlighted the need for active parental involvement in children's technology use, integration of media literacy into school curricula, and the implementation of robust policies to protect children online. Similarly, Hammond et al. (2023) emphasized that enhancing digital resilience is a shared responsibility that involves not only children but also parents, educators, caregivers, civil society, and policymakers. A systematic review by Vissenberg et al. (2022) concluded that while negative online experiences can harm youths' psychosocial well-being, they are also essential for building digital resilience. Moreover, the review identified a protective link between digital literacy (DL) and online resilience. Supporting this, Lee and Hancock (2023) demonstrated that an intervention aimed at improving primary school students' digital skills, self-efficacy, and attitudes toward peer support increased resistance to online risks.

DL has been highlighted as an effective strategy for mitigating such adverse outcomes. Specifically, enhancing children's DL skills and promoting healthy internet habits are crucial in preventing PMU (Gong & Popescu, 2025; Theopilus et al., 2024; Tso et al., 2022). While the relationships between PMU and loneliness (Alheneidi et al., 2021; Youssef et al., 2020), as well as between PMU and DL (Arslantaş et al., 2024; Gong & Popescu, 2025), have been examined separately, the combined relationships among PMU, loneliness, and DL in children remain unclear. While previous studies have primarily focused on the direct relationship between problematic media use (PMU) and loneliness in children, only a limited number of studies have examined the role of DL in this relationship. Studies that conceptualize DL not only

as a general skill but also as a potential mediator between PMU and loneliness remain scarce (e.g., Kim & Lee, 2023, 2024). In this context, the present study focuses on examining whether DL statistically accounts for the association between loneliness and PMU. Therefore, this study aims to explore the interrelationships between PMU, loneliness, and DL in primary school children. The following sections elaborate on these associations and discuss the research's theoretical framework.

2 Literature review

2.1 Problematic media use

Since the emergence of the World Wide Web in 1990, digital technologies—ranging from computers and smartphones to a vast array of online platforms—have rapidly transformed everyday life (WHO, 2015). What began merely as an electronic communication system has evolved into a complex digital ecosystem that shapes how individuals socialize, work, and access information (Yao & Zhong, 2014). Today, people of all ages rely on the internet for entertainment, communication, and productivity; indeed, digital environments can even enhance aesthetic experiences and support more efficient work processes (Li et al., 2024). Nevertheless, alongside these benefits, scholarly work has increasingly emphasized the negative consequences of digital engagement. Over the past two decades, researchers have documented various maladaptive patterns of use—including internet addiction, social media use disorder, mobile phone addiction, and digital game addiction (Caplan, 2010; Davis, 2001; Domoff et al., 2020)—highlighting the complexities embedded within the digital landscape.

PMU has emerged as a broad construct encompassing excessive, maladaptive, and developmentally inappropriate interactions with digital media (Davis, 2001). Unlike earlier notions that focused narrowly on internet addiction, PMU includes a wide array of behaviors involving televisions, smartphones, tablets, and video games. The central premise is that digital media may become a coping mechanism for individuals experiencing cognitive distortions or psychological difficulties, reinforcing dysfunctional use patterns over time. Significantly, PMU is not determined solely by the quantity of screen time; rather, it is defined by the extent to which media engagement disrupts children's daily routines, emotional regulation, and social relationships (Domoff et al. 2019a, b, 2020). These disruptions underscore the need for developmental and behavioral indicators to distinguish normative media use from clinically concerning patterns.

Building on this perspective, Caplan (2003, 2010) proposed the Generalized Problematic Internet Use (GPIU) model, arguing that individuals often use the internet as a coping strategy for psychosocial challenges such as depression and loneliness. Such reliance may gradually evolve into compulsive internet use, impairing academic, occupational, and social functioning. Recent epidemiological evidence indicates that PMU is increasingly prevalent among children. For example, Szapary et al. (2024) reported that more than 10% of Hungarian students in grades 5–8 met the criteria for problematic internet use. In Russia, Alwaely et al. (2023) found that 31% of parents

reported daily child internet use of 3–4 h, while 69% reported usage exceeding four hours. These alarming trends align with growing concerns about the impact of digital media on children's well-being. PMU has been linked to a range of adverse outcomes, including depression, anxiety, attention deficit hyperactivity disorder (ADHD), substance use (Kim et al., 2019), sleep disorders (Domoff et al. 2019b), social anxiety (Wu et al. 2024a), and diminished life satisfaction (Marttilla et al., 2021). Furthermore, a consistent body of research demonstrates a robust association between PMU and loneliness, with studies by Moretta and Buodo (2020), Marttilla et al. (2021), and Yao and Zhong (2014) all confirming this relationship.

Recent evidence underscores that PMU is not only a concern for adults or adolescents but is also increasingly prevalent among younger children. Studies with primary school and preschool populations reveal consistent patterns: PMU is positively correlated with bullying victimization and depressive symptoms (Zhang & Wu, 2024), compulsive digital use is linked to higher loneliness scores in school-age children (Hamad et al., 2023), and excessive screen use is associated with weaker social skills and increased feelings of loneliness in preschoolers (Bakırcı & Çetingöz, 2025). Research with primary school students further shows that screen addiction is positively associated with loneliness and bullying involvement (Uğur & Ergün, 2025). Current global statistics also highlight the educational urgency of PMU. For example, Chinese elementary students spend an average of 2.60 h per day on screens (Liu et al., 2022), children aged 0–8 in the United States use screen media for approximately 2.5 h daily (Rideout & Robb, 2020), and a systematic review across 53 studies found that children aged 6–14 spend an average of 2.77 h on screens daily (Qi et al., 2023). In Türkiye, 87.9% of children aged 6–10 use the internet, and 75.7% play digital games, while 63.5% of children aged 0–12 exceed 120 min of daily screen exposure (TÜİK, 2024; Celep et al., 2024). These findings collectively demonstrate that PMU begins early and is widespread across childhood, carrying developmental risks ranging from language delays (Bhutani et al., 2024) to sleep problems, emotional difficulties, and academic impairment (Rega et al., 2023).

2.2 Children's loneliness

Loneliness is a subjective and distressing emotional state that results from a perceived discrepancy between the social relationships one desires and those one actually experiences (Heinrich & Gullone, 2006). Although loneliness can arise at any age, childhood represents a particularly sensitive developmental window. Early and middle childhood are characterized by rapid cognitive, social, and emotional maturation (Berk, 2015; Peplau & Perlman, 1982), and children in this period rely heavily on stable relationships with family members and peers to develop a sense of belonging and competence (Erol & Köksal, 2025). When these social bonds are weak or inconsistent, loneliness may emerge, negatively affecting children's social adjustment, motivation, and school engagement (Krause-Parello, 2008). Empirical findings show that loneliness in primary school children is linked to a range of socio-emotional difficulties. For example, loneliness is associated with higher social anxiety and lower self-esteem (Li et al., 2022), as well as reduced happiness, weaker independence skills, and lower satisfaction with parental relationships (Wang et al.,

2024). Children aged 8–10 often report experiencing loneliness in school environments, manifested through boredom, withdrawal, and difficulties in peer interactions (Berguno et al., 2004). Prolonged loneliness may undermine children's social competence, increase internalizing symptoms such as anxiety and depression, and impair academic functioning (Luan, 2022). Moreover, loneliness in childhood has long-term implications for health, socio-emotional well-being, and future educational trajectories (Jefferson et al., 2023).

Loneliness in primary school differs meaningfully from loneliness in adolescence due to developmental motivations and social-cognitive capacities. Primary school children are still developing foundational social skills such as perspective-taking, emotional regulation, conflict resolution, and cooperative play (Berk, 2015). Unlike adolescents—who seek autonomy, identity exploration, and complex peer group belonging—children in early and middle childhood depend primarily on immediate, concrete peer acceptance and consistent adult support. Their social worlds are more miniature, more structured, and less flexible (Fussner et al., 2018; Pittman, 2015). When a child experiences peer rejection or lacks stable friendships, the emotional impact tends to be more immediate and less compensated for by alternative social networks (Sette et al., 2017). As digital technologies increasingly permeate children's daily lives, loneliness has become intertwined with digital coping behaviors. Some children may turn to digital environments to alleviate social discomfort or compensate for perceived social gaps (Pittman, 2015). Studies show that loneliness is associated with various forms of digital overuse among children, including screen addiction (Günel & Ergün, 2025), excessive internet use (Yao & Zhong, 2014), and problematic digital gaming (Erden & Bulut, 2023). As loneliness increases, children's reliance on digital media for social connection or emotional regulation may also rise, heightening the risk of PMU.

2.3 Digital literacy

DL refers to a set of competencies encompassing the ability to access, manage, understand, integrate, evaluate, and synthesize information safely and appropriately through digital technologies and produce new media content (Law et al., 2018). DL involves selecting accurate information, using it wisely, and avoiding potential risks in digital environments (Tomczyk, 2020; Vissenberg et al., 2022). This competency includes computer literacy, information, and communication technology (ICT), information literacy, media literacy, the effective use of digital media, and awareness of digital security threats (Law et al., 2018; Martin, 2006). While the global definition of DL proposed by Law et al. (2018) provides a comprehensive and widely accepted framework, it is primarily conceptualized for adolescents and adults. For younger children, DL encompasses a more developmentally appropriate set of competencies. Research shows that critical thinking when using digital tools, selecting accurate, bias-free information, using digital platforms functionally and purposefully, maintaining e-safety and privacy, and participating appropriately in digital communication (Katyetova & Issabayeva, 2025; Fakhrudin & Haryanto, 2023). These competencies are fostered through school-based practices such as integrating DL across subject areas, encouraging collaboration among teachers, administrators, and fami-

lies, and promoting psychosocially supportive learning environments (Kailani et al., 2021; Suwarto et al., 2022).

DL has become a critical skill for survival in today's digital age (Qin et al., 2024; Tomczyk, 2020). The system of knowledge, skills, and strategies used in digital environments enables individuals to function effectively in this environment (Eshet-Alkalai, 2004). Those with such skills are likely to benefit in areas such as the economy, education, social participation, and access to information (Qin et al., 2024). The ability to use information and communication technologies efficiently and recognize and mitigate their negative consequences is closely linked to the level of DL development (Tomczyk, 2020). A study conducted in Indonesia found that DL positively affected children's self-regulation and their capacity to manage online risks (Purnama et al., 2021). Similarly, Gong and Popescu (2025) reported that DL interventions could reduce internet addiction and improve social skills. Theopilus et al. (2024) proposed enhancing children's DL as a preventive intervention to promote healthy internet use. Teaching DL at an early age supports not only the acquisition of basic digital skills but also the development of logical and algorithmic thinking skills (Katyetova & Issabayeva, 2025). In contrast, daily screen time and unsupportive parenting practices are associated with greater digital dependence (Akar & Özer, 2025).

However, in addition to studies highlighting DL's role in preventing dependence on internet-based tools, some research has found a contrary association—suggesting that DL may also be linked to increased levels of digital dependency. For example, Jeong and Bae (2022) identified a positive correlation between DL and smartphone addiction, indicating that higher levels of DL may be associated with greater smartphone dependency. In a similar vein, a study by Özsarı and Görücü (2023) found a positive, albeit weak, correlation between DL and digital addiction. Furthermore, Helsper and Smahel (2019) reported that DL was positively associated with excessive internet use. Their findings suggest that children who report higher internet skills and broader engagement with online content are more likely to encounter the negative consequences of excessive internet use. These mixed findings underscore the need for further research to clarify the role of DL in shaping digital behaviors. The inconsistencies in the current literature suggest that DL may play a more complex role in preventing PMU and potentially enabling it.

2.4 Theoretical framework

From a theoretical perspective, the associations among PMU, loneliness, and DL can be interpreted within several frameworks. First, the Uses and Gratifications Theory (UGT) (Ruggiero, 2000) suggests that children actively turn to digital media to satisfy emotional and social needs—including coping with loneliness—which may increase their reliance on online environments and heighten vulnerability to problematic use. Second, Bronfenbrenner's Ecological Systems Theory (Bronfenbrenner & Morris, 2007) provides a contextual lens for understanding how children's digital behaviors emerge from interactions among multiple environmental layers, including family routines, school climate, parental mediation, and peer relationships. This implies that both DL and PMU should be conceptualized as embedded within broader developmental systems rather than as isolated skills or behaviors. The Interactional

Theory of Childhood PMU (Domoff et al., 2020) posits that children's problematic media behaviors develop through dynamic interactions among child characteristics, family factors, and contextual stressors.

The literature is conflicting on whether DL serves as a protective or risk factor. To explain this contradiction, the UGT and the Ecological Systems Theory may be helpful (Bronfenbrenner & Morris, 2007; Ruggiero, 2000). According to these theories, individuals actively use digital tools to meet their own needs, and the influence of their immediate environment shapes their usage patterns. Therefore, while high DL equips individuals with the skills to access and utilize online resources, in the absence of conscious parental or adult support, it may become a risk factor. The protective or risk-enhancing effects of DL may depend on individuals' media use motivations, emotional states, and environmental context. Thus, DL should not be viewed merely as a standalone competence, but rather as a dynamic construct shaped by the child's surrounding environment. Together, these theoretical perspectives explain why loneliness may drive children toward digital environments, how DL may shape their engagement, and why PMU becomes more likely under certain emotional and social conditions.

2.5 Current study

With the rapid expansion of digital media tools, children's exposure to online environments has increased substantially in recent years (Alheneidi et al., 2021; Alwaely et al., 2023; Szapary et al., 2024; Tso et al., 2022). This surge in digital engagement has been linked to a wide range of adverse psychological and behavioral outcomes, including heightened levels of loneliness, anxiety, PMU, excessive internet engagement, and emotional–behavioral difficulties (Barani et al., 2025; Hosokawa & Katsura, 2018; Kim et al., 2019; Moretta & Buodo, 2020; Yao & Zhong, 2014). Primary school–aged children constitute a particularly vulnerable population, given their limited self-regulatory capacities and developing socio-emotional competencies (Roth et al., 2024). Indeed, studies examining both children and adolescents show that problematic internet and social media use is associated with increased loneliness, depressive symptoms, and reduced life satisfaction (Marttilla et al., 2021; Wu et al. 2024a). A large body of literature consistently demonstrates a positive association between loneliness and multiple forms of digital addiction, including problematic internet use, social media addiction, and smartphone dependence (Moretta & Buodo, 2020; Saadati et al., 2021). Furthermore, excessive mobile device use has been shown to disrupt sleep routines and hinder children's social development (Domoff et al. 2019b; Hosokawa and Katsura 2018). Recent evidence also reports a significant, positive association between loneliness and screen addiction among school-aged children (Günel & Ergün, 2025).

Beyond socio-emotional difficulties, research reveals that media exposure in early and middle childhood influences attention, executive functioning, and broader developmental processes. A systematic review by Nikkelen et al. (2014) identified a positive association between screen exposure and attention problems, while longitudinal analyses by Tomopoulos et al. (2010) demonstrated that infants' early exposure to media—particularly content designed for older children or adults—predicted poorer

cognitive and language development months later. More recent findings continue to highlight these developmental risks. For example, Zhang et al. (2024) reported a significant association between PMU and maternal phone overuse among preschool children, noting that child extraversion moderated this relationship. Similarly, research from China underscores the need to limit smartphone use to reduce academic stress among older children and adolescents (Liu et al., 2022). Complementary evidence shows small but significant links between increased screen time and children's behavioral problems (Eirich et al., 2022) and between excessive screen exposure and delays in language development among children under 12 years old (Bhutani et al., 2024).

Systematic reviews focusing on PMU in younger populations further reinforce these concerns. Rega et al. (2023), synthesizing findings from 35 studies on children aged 10 and under, reported that daily media exposure exceeding two hours substantially heightens the risk of PMU, with gaming addiction emerging as the most prevalent problematic behavior. Their review identified strong associations between PMU and behavioral problems, sleep disturbances, depressive symptoms, low emotional intelligence, and diminished academic performance. Similarly, Fischer-Grote et al. (2019) found that smartphone use—particularly for gaming and social media—constitutes a consistent risk factor for problematic use, whereas having stable, high-quality friendships serves as a protective factor. These findings suggest that PMU not only undermines children's cognitive, linguistic, and socio-emotional development but also intensifies their vulnerability to social challenges such as loneliness. Evidence from early and middle childhood indicates that increases in problematic gaming, smartphone overuse, or compulsive digital engagement are associated with heightened loneliness (Hamad et al., 2023 Kök Eren & Örsal, 2018; Li et al., 2021; Uğur & Ergün, 2025). Further indicates that excessive screen exposure limits real-world social opportunities, weakens peer interactions, and contributes to perceived social isolation (Bakırcı & Çetingöz, 2025).

Within this developmental context, DL may play a key mediating role in the linkage between PMU and loneliness. As a foundational skill enabling individuals to use digital technologies safely, critically, and responsibly, DL is commonly regarded as a protective factor against digital dependency and online risks (Barani et al., 2025; Purnama et al., 2021). However, empirical findings on this relationship remain mixed. While some studies report inverse associations between DL and problematic digital engagement, others find that higher DL may coincide with greater digital dependency—potentially reflecting contextual, developmental, or motivational differences (Arslantaş et al., 2024; Jeong & Bae, 2022). These contrasting patterns underscore the need to examine DL within specific populations and usage contexts, particularly in childhood, when digital habits and socio-emotional vulnerabilities co-evolve. The present study seeks to investigate the association between PMU and loneliness among primary school children, and to determine whether DL mediates this relationship. The following research questions guided the study, and the proposed conceptual model is illustrated in Fig. 1:

- Is there a statistically significant relationship between loneliness, PMU, and DL among primary school children?

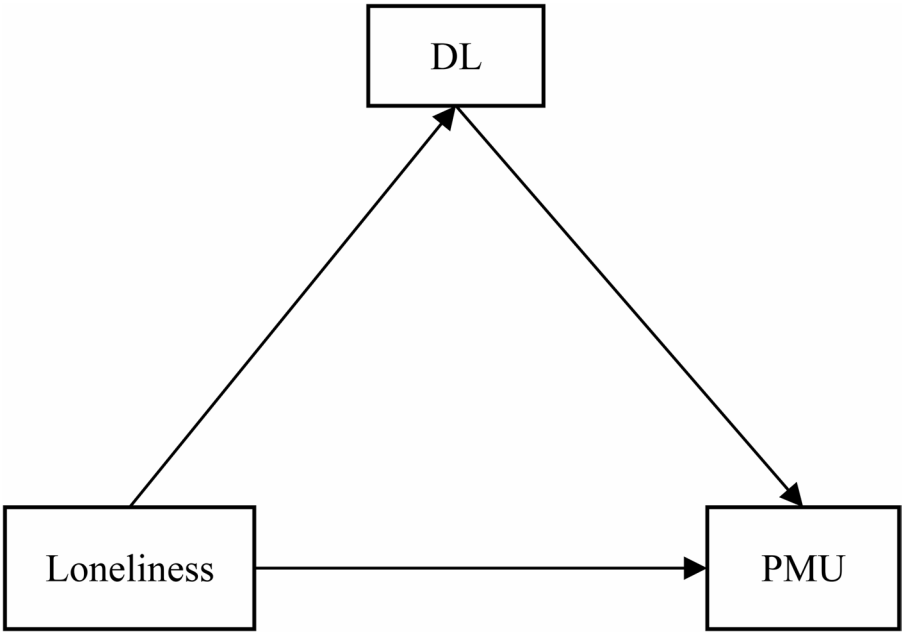

Fig. 1 Conceptual model

- Does DL serve as a mediator in the relationship between loneliness and PMU in primary school children?

3 Method

3.1 Participants

The participants in this study were 957 children aged 8–11 enrolled in various public primary schools across Türkiye. A total of 53 classrooms from 12 schools were included in the study. Criterion sampling, a purposive sampling technique, was used to select participants. Two primary inclusion criteria were used to select the children. First, participants were required to have a basic level of Turkish language proficiency to ensure the validity of their interactions in the educational setting and their responses to the measurement instruments. Second, the children had to be enrolled in the same grade level within a primary school. This criterion was adopted to ensure that participants shared comparable educational experiences and that the collected data would be mutually comparable. Regarding the sample's demographic characteristics, 48.7% of the children were boys ($n=466$), and 51.3% were girls ($n=491$). Regarding grade level, 49.7% of the children were in the third grade, and 50.3% were in the fourth grade.

3.2 Measurement instruments

The psychometric measurements and measurement tools used in this study are summarized in Table 1.

3.2.1 Problematic media use measure – short form (PMUM-SF)

The PMUM-SF was developed specifically for children aged 4–11, based on parent-report indicators of problematic screen media use (Domoff et al. 2019a). The scale was adapted into Turkish by Furuncu and Öztürk (2020). The Turkish adaptation study used parent reports of children within a similar age range, and the scale's psychometric properties (factor structure, reliability, and item characteristics) were validated for this developmental group (Furuncu & Öztürk, 2020). In this study, the short form of the instrument, consisting of 9 items, was employed. The scale is completed by parents based on their observations of their child's media use and is rated on a five-point Likert-type scale ranging from 1 (Never) to 5 (Always). Higher scores indicate a greater tendency toward PMU. The scale is unidimensional and encom-

Table 1 Summary of reliability and validity for PMUM-SF, loneliness, and DL

Scale	Structure	Items	CFA Fit Indices	Reliability Indices
PMUM-SF	Unidimensional	9 items	RMSEA = 0.062 CFI = 0.99 SRMR = 0.041	α (adaptation): 0.90 α (current study): 0.91
Loneliness	Unidimensional	24 items	χ^2/df = 3.07 GFI = 0.90 AGFI = 0.90 CFI = 0.90 NFI = 0.90 NNFI = 0.91 RMSEA = 0.049	α (adaptation) = 0.82 Test–retest = 0.82 α (current study): 0.84
DL	Three-factor model	16 items	χ^2/df = 2.84 RMSEA = 0.049 GFI = 0.92 AGFI = 0.96 NFI = 0.97 CFI = 0.95	α subscales: Purpose of use = 0.803, Technical knowledge = 0.792, Privacy and security knowledge = 0.765 α (current study): 0.81

passes behavioral indicators related to screen media addiction, including symptoms such as tolerance, withdrawal, and mood regulation through media use. The PMUM-SF was developed to assess behavioral indicators related to children's media use (e.g., tolerance, withdrawal) and is administered based on parent reports (Domoff et al. 2019a).

Although the scale generally refers to "screen media use," it does not explicitly differentiate between specific media types such as social media, video games, or television. However, given the developmental characteristics of the target age group, the items primarily reflect behaviors associated with audio-visual content (e.g., cartoons, YouTube videos, mobile games), rather than with interactive social media platforms that older children or adolescents more commonly use. According to the exploratory factor analysis (EFA), the scale explains 62.8% of the total variance, with item factor loadings ranging from 0.53 to 0.84 and item-total correlations ranging from 0.54 to 0.85. This level of explanation is acceptable; however, the model still cannot account for a significant portion of the variance. This suggests that the structure could be strengthened by adding more variables. Validity and reliability values of the scale are presented in Table 1. Sample items include:

"It seems like visual media is the only thing my child is interested in."
"My child becomes frustrated or upset when he/she cannot use visual media."

3.2.2 Children's loneliness scale

Asher et al. (1984) originally developed the Children's Loneliness Scale to assess primary school children's satisfaction with peer relationships and perceptions of social exclusion. Duyan et al. (2015) carried out the Turkish adaptation of the scale. The scale consists of 24 items and is administered using a 5-point Likert scale (1 = Always true, 5 = Not at all true). The scale jointly measures loneliness and perceived social acceptance. It includes positively and negatively worded items, with certain items reverse-scored. The Cronbach's alpha reliability coefficient was reported as 0.82. The test-retest reliability was also 0.82. Item-total correlation values ranged from 0.33 to 0.52. The minimum score is 16, and the maximum is 80. Higher scores on the scale indicate greater loneliness. Validity and reliability values of the scale are presented in Table 1. Sample items include:

"I feel alone."
"It is hard for me to make friends."
"I can find a friend when I need one."
"I feel like other kids do not include me."
"I have many friends."

3.2.3 Digital literacy scale

The DL Scale was developed by Şahin et al. (2022) to assess how primary school children use digital technologies. The scale consists of 16 items and has a three-factor structure designed to evaluate children's use of digital technologies regarding

information access, content creation, safe usage, and information sharing. The three subscales are as follows: (1) Purpose of Use, (2) Technical Knowledge, (3) Privacy and Security Knowledge. Items are rated on a 3-point Likert scale (1 = Disagree, 2 = Partially Agree, 3 = Agree). According to the EFA, the scale accounts for 54.66% of the total variance, with factor loadings ranging from 0.58 to 0.81. Although the explained variance of 54.66% falls within the acceptable range for three-factor structures in social sciences, it indicates that a notable portion of the construct remains unexplained (Henson & Roberts, 2006). The scale captures the core components of DL but may not fully encompass its broader multidimensional nature, which should be considered when interpreting the findings. Validity and reliability values of the scale are presented in Table 1. Sample items include:

"I use digital devices to read books" (Purpose of use),
"I set passwords on my digital devices for safety" (Privacy and security).

3.3 Procedure and ethical considerations

Prior to data collection, ethical approval was obtained from the ethics committee of a public university, and the necessary permission was subsequently granted by the Ministry of National Education. To ensure consistency across participating schools and classrooms, data collection followed a standardized procedure. After institutional approvals were secured, the research team visited each school and informed classroom teachers about the purpose and structure of the study. The child-report instruments were administered during regular class hours in quiet classrooms with minimal distractions. At the beginning of each session, children were given a brief explanation of the procedure and informed that participation was voluntary. The Loneliness Scale and the DL Scale were completed individually under the supervision of the researcher and the classroom teacher in paper-and-pencil format, and the administration took approximately 15–20 min.

Because the PMUM-SF is a parent-report measure, the forms were sent home with students in sealed envelopes and distributed by classroom teachers. Parents were asked to complete the measure independently based on their observations and return it to the school within one week. Completed forms were collected in sealed envelopes and delivered to the research team to maintain confidentiality. All forms were checked for missing data and transferred to a digital dataset by a trained research assistant. To ensure accuracy, the dataset was reviewed twice before analysis. The entire data collection and entry process was completed over a five-week period.

Ethical principles were observed throughout all stages of the study. The purpose, scope, and procedures of the research were explained to teachers and parents in accessible language before administration. Written informed consent was obtained from parents, and participation was entirely voluntary. Parents and children were informed that they could withdraw from the study at any time without penalty and that non-participation would not result in any negative consequences. No personally identifying information was included in the dataset or reports. Throughout the research process, the principles of confidentiality, transparency, voluntary participation, and scientific integrity were carefully maintained.

3.4 Data analysis

3.4.1 Preliminary analyses

Several statistical assumptions were tested to assess the suitability of the data for analysis. First, univariate normality was evaluated using skewness and kurtosis. All variables fell within the acceptable range of ± 1.5, indicating an approximately normal distribution (Tabachnick & Fidell, 2015). Multivariate normality was assessed using Mardia's skewness and kurtosis coefficients (George & Mallery, 2010). The Mardia test returned significant results ($p < .001$), indicating a violation of multivariate normality. Therefore, Robust Maximum Likelihood (MLR) estimation was employed for confirmatory factor analyses (CFA). The risk of multicollinearity was evaluated using Pearson correlation coefficients and Variance Inflation Factors (VIFs). The absence of correlations above 0.80 among variables (Finney & DiStefano, 2006) and VIF values below 10 (Field, 2013) confirmed that multicollinearity was not a concern. The internal consistency of the scales was assessed using Cronbach's alpha, and all scales demonstrated coefficients above the recommended threshold of 0.70. Model fit was interpreted using the following conventional criteria: $\chi^2/df < 5$, CFI ≥ 0.90–0.95, TLI (NNFI) ≥ 0.90–0.95, RMSEA ≤ 0.08–0.05, SRMR < 0.08, and NFI, IFI, RFI ≥ 0.90 (Byrne, 2010; Hu & Bentler, 1998; Marsh et al., 2004).

3.4.2 Main analyses

After confirming the adequacy of the measurement models through CFA, the hypothesized indirect association was tested using a regression-based mediation analysis rather than full structural equation modeling. This approach was preferred because the study aimed to examine the indirect association among observed composite scores rather than to estimate a full latent structural model. Accordingly, the mediation analysis was conducted in Jamovi (version 2.3.38) using the jAMM module. First, descriptive statistics and Pearson correlations were calculated for all study variables. Next, a regression-based mediation model was tested to examine whether DL statistically accounted for the association between loneliness and PMU. Direct, indirect, and total effects were estimated, and the significance of the indirect effect was evaluated using bias-corrected bootstrap confidence intervals based on 2,000 resamples (Hayes, 2017). Because the aim was to test the indirect association at the observed-variable level, this analytic strategy was considered appropriate for the present study.

4 Findings

4.1 Descriptive statistics and correlation analysis

As presented in Table 1, the mean score for children's loneliness was 31.9, the mean for DL was also 31.9, and the mean score for PMU was 17.9. Skewness and kurtosis values for all variables were within the acceptable range of ± 1, indicating normal distribution. A positive and statistically significant correlation was found between

loneliness and PMU (r = .24). Additionally, a moderate and significant association was observed between DL and PMU (r = .32). A statistically significant relationship was also identified between loneliness and DL (r = .23). The observed minimum and maximum scores reflect a wide range in children's experiences and competencies, particularly in loneliness (range = 19–65) and PMU (range = 9–42) (Table 2).

4.2 Measurement model

The psychometric properties of the measurement model—specifically its reliability and validity—were assessed using Cronbach's alpha (α), McDonald's omega (ω), composite reliability (CR), and average variance extracted (AVE). In the current study, the internal consistency coefficients (Cronbach's alpha) were 0.84 for the Loneliness Scale, 0.91 for the PMU Scale, and 0.81 for the DL Scale, indicating high reliability for all instruments used (Tabachnick & Fidell, 2015). Furthermore, the AVE was greater than 0.50 for each construct, indicating sufficient convergent validity. Discriminant validity was established using the Fornell-Larcker criterion (Fornell & Larcker, 1981). The reliability and validity assessments of the measurement model followed the procedures recommended by Fornell and Larcker (1981) and Hair et al. (2019). All constructs demonstrated satisfactory reliability (α, ω, CR > 0.80) and convergent validity (AVE > 0.50) (Hair et al., 2019).

The model fit indices indicated acceptable fit. The SRMR values were below 0.08 for all measurement models, indicating a good fit (Hu & Bentler, 1998). The Normed Fit Index (NFI) values were above 0.90, meeting the acceptable threshold (Bentler & Bonett, 1980). The following specific model fit results were obtained for the data collected from children (Bentler & Bonett, 1980): PMU (unidimensional model): $\chi^2/df = 1.93$, RMSEA = 0.049 [0.03, 0.05], SRMR = 0.04, CFI = 0.93, TLI = 0.94. Loneliness (unidimensional model): $\chi^2/df = 1.68$, RMSEA = 0.04 [0.03, 0.04], SRMR = 0.04, CFI = 0.97, TLI = 0.96. DL (three-dimensional model): $\chi^2/df = 1.97$, RMSEA = 0.02 [0.03, 0.05], SRMR = 0.05, CFI = 0.90, TLI = 0.90.

4.3 Mediation model

The results of according to the findings, the total effect of loneliness on PMU was statistically significant (β = 0.24, $p < .001$, 95% CI [0.1469, 0.2559]). Specifically, the indirect effect of loneliness on PMU via DL was also statistically significant (β = 0.06, $p < .001$, 95% CI [0.0345, 0.0740]). Component-level analyses further showed that loneliness was positively associated with DL (β = 0.23, $p < .001$) and that DL was positively associated with PMU (β = 0.28, $p < .001$). In terms of direct effects, loneli-

Table 2 Descriptive statistics: loneliness, DL, and PMU

Variable	Mean	SD	Skew.	Kurt.	Median	Min.	Max.	1	2	3
1. Loneliness	31.90	8.74	0.561	0.025	31	19	65	—	0.23*	0.24*
2. DL	31.90	5.72	0.108	–0.281	32	17	47		—	0.32*
3. PMU	17.90	7.47	0.842	–0.038	16	9	42			—

*$p < .001$

Table 3 Direct, indirect, and total effects of loneliness on PMU via DL

				95% C.I. (a)				
Type	Effect	Estimate	SE	Lower	Upper	β	z	*P*
Indirect	Loneliness ⇒ DL ⇒ PMU	0.0543	0.0101	0.0345	0.0740	0.0649	5.39	<0.001
Component	Loneliness ⇒ DL	0.1329	0.0192	0.0953	0.1705	0.2310	6.93	<0.001
	DL ⇒ PMU	0.4082	0.0476	0.3149	0.5015	0.2811	8.58	<0.001
Direct	Loneliness ⇒ PMU	0.1471	0.0274	0.0935	0.2008	0.1760	5.37	<0.001
Total	Loneliness ⇒ PMU	0.2014	0.0278	0.1469	0.2559	0.2410	7.25	<0.001

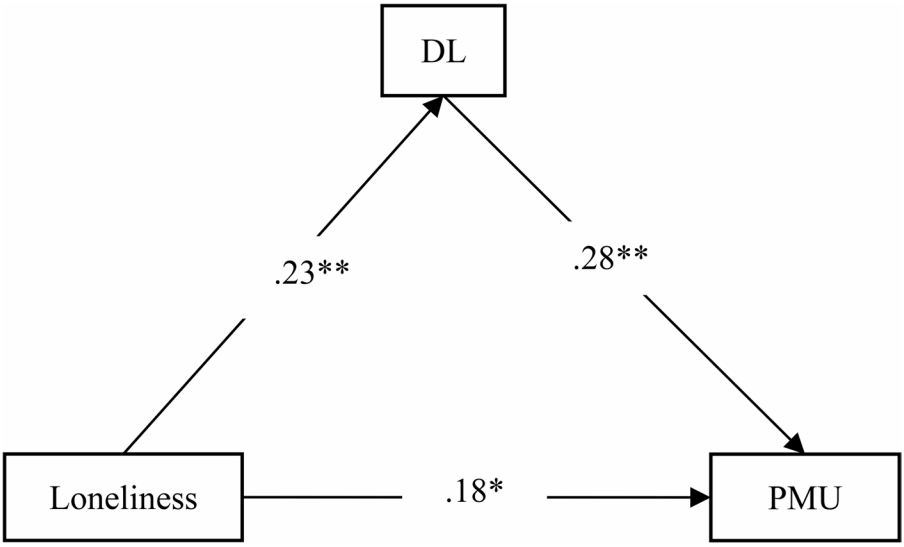

Fig. 2 CMB: Path diagram of the GLM mediation, with β coefficients (*p<.05; **p<.01)

ness remained significantly associated with PMU after accounting for DL (β = 0.18, p < .001, 95% CI [0.0935, 0.2008]) (Table 3).

5 Discussion

This study examined the relationships among PMU, loneliness, and DL in primary school children. We explored the mediating roles of DL in the relationship between loneliness and PMU. Below, we discuss the findings in light of the existing literature and highlight their implications (Fig. 2).

5.1 Relationships between loneliness, problematic media use, and digital literacy

Our findings indicate a significant positive relationship between loneliness and PMU. Specifically, higher loneliness scores were associated with higher PMU levels of digital media tools. This finding is consistent with previous research suggesting

that loneliness has been linked to increased engagement in online social interactions, thereby increasing the risk of excessive or maladaptive media use (Alheneidi et al., 2021; Arslantaş et al., 2024; Barani et al., 2025; Kim et al., 2019; Kim & Lee, 2024; Moretta & Buodo, 2020; Saadati et al., 2021; Small et al., 2020; Tian et al., 2021). For instance, Youssef et al. (2020) found that higher levels of social media use disorder were significantly associated with increased loneliness. Similarly, Marttila et al. (2021) suggested that PMU may exacerbate feelings of loneliness. Wu et al. (2024b) further supported this by identifying loneliness as significantly associated with PMU. O'Day and Heimberg (2021) argued that lonely individuals tend to engage in more problematic online interactions and seek social support through social media to compensate for the lack of face-to-face connections. Likewise, Yao and Zhong (2014) emphasized that excessive and unhealthy internet use may increase feelings of loneliness over time. In this context, UGT provides a vital framework for conceptualizing the motivations underlying the loneliness-PMU relationship revealed in this study, as it explains children's orientation to digital environments not only for entertainment or information, but also for personal needs such as filling emotional voids, seeking social support, or coping with loneliness (Wang et al., 2023).

Another key study finding was the significant association between DL and PMU. While some studies align with this result and suggest that DL contributes to healthier online behavior (Gong & Popescu, 2025; Purnama et al., 2021; Taşkın & Ok, 2022), others have found positive correlations between DL and digital dependency (Özsarı & Görücü, 2023). Zheltukhina et al. (2025) further argued that high levels of media literacy may, in some cases, facilitate rather than reduce problematic behaviors. Our study also found a positive and statistically significant relationship between loneliness and DL. Although this finding may appear counterintuitive at first glance, it can be explained by the evolving nature of social interactions in the digital age. Increased time spent in digital environments may enhance children's ability to access information, communicate online, and engage in digital activities. Children who experience loneliness may be more inclined to turn to digital tools and social media platforms to compensate for the lack of in-person social interactions (O'Day & Heimberg, 2021; Youssef et al., 2020). Within the theoretical foundations of this study, Ecological Systems Theory emphasizes that children's digital behaviors are shaped not only by individual characteristics but also by multilayered environmental factors, such as family routines, parental supervision, teacher guidance, and peer relationships. From this perspective, the risk-increasing function of DL in some situations becomes more understandable when considered alongside the child's socio-emotional context (Arnott, 2016; Liu & Wu, 2024). This process may help develop DL skills such as navigating digital devices, accessing online content, evaluating information, and producing media.

Particularly, as children spend more time on social media, gaming platforms, or other online communities to alleviate feelings of loneliness, they also gain increased opportunities to practice key components of DL, such as accessing information, sharing content, and ensuring online safety (Law et al., 2018). In this context, it can be suggested that loneliness may indirectly support the development of DL by increasing children's engagement with digital tools (O'Day & Heimberg, 2021; Youssef et al., 2020). In certain situations, they may even be associated with a higher risk of

excessive digital involvement, according to studies (Helsper & Smahel, 2019; Jeong & Bae, 2022). This seemingly counterintuitive finding warrants further investigation. Future research could use qualitative methods to gain a more nuanced understanding of how children's emotional states influence their digital engagement, and the complex role DL plays in this process (Kim & Lee, 2023, 2024; Vissenberg et al., 2022).

5.2 Mediation model

The mediation analysis showed that DL statistically accounted for part of the association between loneliness and PMU. The easy accessibility, unlimited interaction opportunities, and highly stimulating content offered by digital environments may encourage lonely individuals to seek refuge online, and having a higher DL may allow them to navigate and utilize these platforms more actively and extensively. These findings are consistent with several previous studies. For example, Kürtüncü et al. (2021), in a study conducted in Türkiye, reported that as adolescents' smartphone addiction increased, their feelings of loneliness decreased, suggesting that children may attempt to cope with loneliness by seeking social interaction in online spaces. Similarly, Jeong and Bae (2022) found that individuals with higher levels of DL also reported higher levels of smartphone addiction. Helsper and Smahel (2019) likewise observed that children with more advanced internet skills tended to spend more time online, increasing their risk of experiencing the negative consequences of excessive internet use. However, not all findings in the literature are consistent. For instance, Kul (2020) found no significant relationship between DL and internet addiction.

Although the effect sizes observed in this study are statistically significant and fall within the small-to-moderate range (Cohen et al., 2007), they still have meaningful implications for educational practice. Given the complexity of children's psychological and behavioral outcomes, even modest effects can signal critical intervention points—especially when they involve widespread issues such as loneliness and PMU. In large-scale educational or psychological interventions, small effects can translate into substantial impacts when applied across broader populations (Prentice & Miller, 1992).

6 Limitations and future direction

This study has limitations. The participants were from a specific geographic region, limiting the generalizability of the findings. Future research should involve diverse samples from different areas and demographic backgrounds. Additionally, the data relied on both child self-reports and parental assessments, which may introduce measurement bias. While loneliness and DL were based on children's self-perceptions, PMU was measured through parent-completed PMUM-SF forms. Another limitation concerns the cross-sectional nature of the study. Although the mediation model was used to examine whether digital literacy statistically accounted for part of the association between loneliness and PMU, the study design does not permit conclusions about temporal ordering or directional influence among these variables.

Therefore, the findings should be interpreted as indicating statistical associations rather than causal pathways. Longitudinal and experimental studies are needed to clarify whether loneliness predicts later PMU, whether PMU intensifies loneliness over time, or whether these relationships are reciprocal. Future experimental studies could assess the effectiveness of educational programs designed to improve children's DL competencies. Strategies such as strengthening digital knowledge and competencies, helping parents regulate children's internet use, encouraging physical activity, and seeking professional counseling when needed may be effective (Theopilus et al., 2024). Given the vulnerability of young internet users, multi-stakeholder engagement—including parents, teachers, and peers—is essential to the design of successful interventions. Age-appropriate digital tools may also play a critical role in mitigating PMU (Theopilus et al., 2024).

DL education in schools should not be limited to technical skills; children must also be equipped with critical thinking abilities, safe content selection strategies, online risk awareness, and self-monitoring skills for media use. Teachers should design media literacy modules that address not only cognitive aspects but also support emotional and social development. Parents can promote healthy digital habits by reviewing content with their children, establishing consistent screen-time routines, and setting clear household rules. Strengthening family–school collaboration through school-based programs and parent workshops will enhance children's DL skills and help integrate them into balanced, responsible media use.

7 Conclusions

The findings show that loneliness shows both direct and indirect associations with PMU, with DL accounting for part of the association between loneliness and PMU. Importantly, DL did not consistently function as a protective factor; in some cases, higher levels of digital competence were associated with greater vulnerability to problematic media behaviors, especially among children experiencing elevated loneliness. The findings contribute to ongoing debates about whether DL mitigates or amplifies digital risks. The results support perspectives suggesting that technical digital skills, when not accompanied by emotional and social competencies, may increase children's exposure to maladaptive digital engagement. In practical terms, the study underscores the need to broaden DL education beyond instrumental or technical components.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest There is no conflict of interest between the authors or other persons/institutions/organizations in the study.

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