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Surfing into trouble? How internet use influences early adolescent behavior through diverse pathways?

Xingchen Zhu¹, Wencan Li², Haohan Zhao³✉ & Jinsheng Hu¹✉

In the digital age, the escalating accessibility of the Internet to younger populations prompts significant concerns about its potential behavioral repercussions. The objective of this research is to investigate the connection between Internet use and externalizing problem behaviors in early adolescents. A total of 1155 Chinese early adolescents, ranging in age from 11 to 14 years, participated by completing an anonymous self-report questionnaire. The findings reveal that: (1) there is a positive correlation between the extent of Internet use and the prevalence of externalizing problem behaviors, suggesting a potential risk factor inherent in unregulated digital exposure; (2) both self-education expectations and peer relationships mediate the link between Internet use and externalizing problem behaviors, indicating that educational aspirations and social interactions play a pivotal role in mediating this impact; (3) Internet use indirectly influences externalizing problem behaviors through the sequential mediation of self-education expectations and peer relationships, outlining a complex interplay that influences behavioral outcomes; and (4) the influence of Internet use on externalizing problem behaviors shows notable differences based on gender and geographical location, with a greater adverse impact observed in males than in females and in rural settings compared to urban areas. These findings underscore the urgent need for bespoke strategies to mitigate the negative influences of Internet use on youth, tailored to address the specific challenges faced by different demographic groups. The study not only extends the current understanding of digital media's impact on adolescent behavior but also catalyzes policy discussions aimed at fostering healthier digital environments for the younger generation.

¹ College of Psychology, Liaoning Normal University, Dalian, Liaoning, China. ² Faculty of Education, East China Normal University, Shanghai, China. ³ School of Chinese Language and Literature, Liaoning Normal University, Dalian, Liaoning, China. ✉email: zhzh@lnnu.edu.cn; hu_jinsheng@126.com

Introduction

The data from the United Nations Children's Fund highlights that adolescents constitute approximately one-third of the global Internet users, with an additional adolescent joining the digital sphere approximately every 30 s (United Nations Children's Fund, 2018). Additionally, by the conclusion of 2021, China reported over a billion Internet users. Notably, adolescents aged below 19 years accounted for an estimated 182 million, representing a significant demographic segment (China Internet Network Information Center, 2022). The "Youth Blue Book" provides a detailed examination of the online behaviors exhibited by Chinese middle school students, noting an emphasis on academic pursuits, yet accompanied by sustained leisure-driven online engagements, which pose a potential risk of overuse (CASS and SSAP, 2022).

The Internet represents a vast and diverse realm, offering a wide array of informational and entertainment resources, such as gaming. These resources cater to the intellectual curiosity and knowledge-seeking propensities of adolescents (Kahila et al. 2021; Kormas et al. 2011). Submerged in this information-rich environment and digital applications, the cognitive frameworks and behavioral tendencies of adolescents exhibit pronounced digital characteristics, leading to their classification as 'digital natives' (Thompson 2013). The immersion in digital culture has become a defining aspect of adolescent development, shaping their cognitive and social skills in unique ways (Livingstone et al. 2023). Notably, early adolescence is identified as a phase of intensified arousal, rendering individuals particularly susceptible to challenges in regulating emotions and behavior (Arnett 1999; Steinberg 2005). During this critical developmental stage, adolescents assimilate external influences into their social behaviors (Sun and Du 2020), characterized by a heightened propensity for imitation and exploration, accompanied by a spectrum of problematic behaviors (Jaworska and MacQueen 2015).

"Problem behavior" is a term denoting atypical behavioral patterns that impede an individual's social adaptation (Ramazan and Unsal 2012; Achenbach et al. 1987). These behaviors can be classified into two main categories: internalizing behaviors and externalizing behaviors. Internalizing behaviors encompass emotional and psychological disturbances such as anxiety and depression (Betts et al. 2014). In contrast, externalizing behaviors comprise acts like truancy, physical aggression, alcohol misuse, and other confrontational behaviors (Bishop et al. 2020; Brock and Kochanska 2016). The foundational assumption of problem behavior theory posits that all behaviors arise from the interplay between humans and their environment. Within this framework, the external environment of adolescents is underscored for its pivotal role in eliciting problem behaviors (Bingham and Shope 2004; Karaman 2013). Contemporary research indicates that excessive Internet usage, considered an external environmental variable, can detrimentally affect various facets of adolescents' lives, including academic performance, daily activities, familial relationships, and overall mood (Durak 2019; Fumero et al. 2018; Li et al. 2019; Zhang et al. 2021; Abbasi and Drouin 2019). Furthermore, a robust link has been established between overreliance on the Internet and the manifestation of behavioral problems (King et al. 2018; Piko et al. 2017). For instance, excessive use of social media platforms has been associated with increased levels of anxiety and depression among adolescents (Hu and Zhang 2024). While adolescents explore and express their identities in virtual spaces, this engagement carries an increased risk of exposure to inappropriate content and cyberbullying, potentially exacerbating emotional and behavioral issues (Ip, 2023).

While several studies have explored the direct influence of Internet usage on adolescent problematic behaviors, there has

been limited research focusing specifically on early adolescence and externalizing problem behaviors. Furthermore, there remains a notable gap in the literature regarding the mechanisms underpinning the effects of Internet usage on externalizing problem behaviors in early Chinese adolescents. Additionally, the heterogeneity observed among adolescents, attributable to diverse personality traits, family backgrounds, and socio-economic statuses, necessitates a nuanced exploration of this relationship (Valkenburg and Peter 2013). Given the detrimental consequences of externalizing problem behaviors on adolescent development (Chen et al. 2012; Modecki et al. 2017; Vaillancourt et al. 2013), it is imperative to investigate the mediating mechanisms that link Internet use with these behaviors, and to examine the effects of heterogeneity to understand how individual and contextual factors modulate the impact of Internet use on adolescent behavior. Such understanding not only elucidates the underlying dynamics between Internet consumption and early adolescent externalizing problem behaviors but also fosters effective interventions. Consequently, a comprehensive examination of the correlation between Internet usage and early adolescent externalizing problem behaviors during this developmental phase is both timely and essential.

Literature review

Internet use and early adolescence externalizing problem behaviors. Social Learning Theory (SLT) proposes that learning is a cognitive process occurring within a social context and can transpire through observation or direct instruction, even in the absence of motor reproduction or direct reinforcement (Bandura 1969). This theory is notably pertinent in analyzing adolescent behavior in the digital era, where the Internet constitutes a significant social and learning milieu (Al-Zahrani 2015).

The Internet functions as an extensive reservoir of behaviors, attitudes, and emotional responses, all of which are accessible for adolescents to observe and possibly mimic. This includes a spectrum of behaviors, from positive to negative, with particular relevance to this research being the negative or externalizing behaviors such as aggression, rule-breaking, or other antisocial conduct (Lowry et al. 2016). Observational learning, a fundamental aspect of SLT, is crucial in understanding the adoption of these behaviors by adolescents. The theory posits that individuals, especially those in their impressionable years, learn and replicate behaviors observed in their surroundings, which now predominantly includes the digital spaces they inhabit (Akers 2017).

A key concept within SLT, Bandura's idea of modeling, where individuals imitate others' behaviors, is especially significant in the realm of Internet usage. Adolescents encounter various role models through platforms like social media, video streaming services, and online forums. These role models do not always exhibit behaviors that are socially constructive; they often display behaviors linked to fame, power, or success that are characterized by externalizing elements (Stilgoe 2018). Such exposure may lead adolescents to imitate these behaviors, under the belief that these actions are socially acceptable or desirable.

Reinforcement, another critical element of SLT, also plays a significant role in online environments. Behaviors can be reinforced or discouraged through immediate feedback mechanisms like likes, comments, and shares (Goldie 2016). This dynamic can perpetuate externalizing behaviors if such actions receive positive reinforcement in online communities. Additionally, the relative anonymity afforded by the Internet can embolden users, particularly adolescents, to partake in more audacious behaviors with a diminished fear of immediate real-world repercussions. Zimmerman and Ybarra (2016) explored the

influences of anonymity and social modeling on online aggression, highlighting the significance of anonymity in shaping online behaviors. Barlett (2015) found strong support for the role of anonymity as a predictor of cyberbullying behavior, which aligns with the notion that anonymity can embolden more audacious behaviors in adolescents. Additionally, Ellison et al. (2016) examined how adolescents use selective anonymity on online platforms, suggesting that anonymity plays a complex role in shaping adolescents' online interactions and behaviors.

Empirical research has corroborated the principles of SLT in the context of Internet use. Studies indicate that adolescents frequently exposed to violent or harmful content online are more inclined to exhibit analogous behaviors. For example, research by Brady et al. (2021) elucidated a correlation between online aggression exposure and escalated physical aggression among adolescents. In a similar vein, Zhang et al. (2015) reported that heightened engagement with antisocial online communities correlated with an increased prevalence of rule-breaking behaviors in early adolescents.

Therefore, the use of the Internet is likely to positively predict externalizing problem behaviors in early adolescence.

Self-education expectation as a mediator. Self-education expectation refers to the expectation that individuals place on their future educational level, which plays an important role as an endogenous driving force in the development of adolescents themselves (Yamamoto and Holloway 2010; Wu and Huang 2016). Expectancy value theory states that the production of behavior is related to the subjective value that individuals place on the behavior and the individual's expectation of success (Wigfield and Eccles 2000). Many studies have proven that the self-education expectation has a positive impact on the overall growth and development of adolescents (Davis-Kean 2005; Zhan and Sherraden 2011; Jacob and Wilder 2010).

Self-Determination Theory (SDT) provides a comprehensive framework for analyzing the relationship between Internet use, self-education expectations, and the manifestation of externalizing problem behaviors in early adolescents, with a particular emphasis on the mediating role of self-education expectations. A fundamental aspect of SDT is the distinction between intrinsic and extrinsic motivation (Deci and Ryan 2000). Intrinsic motivation arises from internal rewards, such as personal interest and satisfaction, whereas extrinsic motivation is influenced by external rewards or pressures. Within the context of Internet usage by early adolescents, SDT suggests that usage driven by intrinsic motivations, including the pursuit of self-education and personal growth, is more likely to result in adaptive and positive outcomes (Holzer et al. 2021). Self-education expectations, representing a form of intrinsic motivation, may thus play a pivotal mediating role. Adolescents who possess strong self-education expectations tend to utilize the Internet in a manner congruent with their goals for personal growth and learning (Mills and Allen 2020). Such intentional and autonomous use of the Internet can nurture a sense of autonomy, competence, and relatedness, which are the core psychological needs identified in SDT. The fulfillment of these needs is typically linked to positive developmental outcomes and can act as a protective factor against the emergence of externalizing problem behaviors, often associated with unfulfilled psychological needs and maladaptive coping strategies (Mills and Allen 2020; Lee et al. 2015). Conversely, in scenarios where self-education expectations are lacking, or when Internet usage is primarily extrinsically motivated (for instance, for seeking social approval or as an escape from real-life challenges), it may not effectively support these psychological needs. Such patterns of Internet use might

even amplify feelings of incompetence, social isolation, or a lack of autonomy, potentially contributing to the development of externalizing problem behaviors in adolescents (Wong et al. 2015).

Empirical studies have substantiated the tenets of SDT within the context of Internet use, self-education expectations, and early adolescent externalizing problem behaviors. Adolescence is a critical period in the cognitive, emotional and social development of individuals. Expectations of self-role and future possibilities are the most distinctive features of this period (Yang 2018). Adolescents position themselves as a "want-to-be self" and a "fear-to-be self". A positive "want-to-be self" helps adolescents develop expectation-oriented behaviors, such as becoming more diligent and spending more time on homework (Erikson 1994). High educational expectations also can motivate students to pursue high academic achievement and higher qualifications (Zhan and Sherraden 2011). Therefore, the higher the adolescents' expectations of their own education, the better their academic achievements will be. From the general experience and facts, the better the academic performance of adolescents, the lower the probability of problem behaviors (Markus and Nurius 1986).

Excessive Internet usage has emerged as a concern for adolescents' overall well-being and developmental outcomes. A subset of adolescents turns to the Internet as a means to bolster their self-esteem, inadvertently leading to diminished self-education expectations (Stavropoulos et al. 2013). The consequences of prolonged Internet exposure on adolescents' aspirations for self-education are particularly disconcerting. A study by Su and Sun (2022) found a negative correlation between the duration of Internet use and self-education expectations among adolescents: the more time they spent online, the less ambitious their educational aspirations became. Furthermore, the Internet's vast array of content, while beneficial in many aspects, may sometimes divert adolescents from educational pursuits by offering instant gratification and easier alternatives to hard work (Beland and Murphy 2016). Additionally, the online environment, filled with constant social comparisons via platforms like social media, can also skew perceptions of success and lead to reduced motivation for self-improvement (Chou and Edge 2012). Thus, a comprehensive understanding of the intricate relationship between Internet use and self-education expectations necessitates multifaceted analyses, considering both the direct and indirect influences of online engagements.

Regarding the mechanism among Internet use, self-education expectation and early adolescent externalizing problem behaviors, self-education expectation may possibly produce the intermediary effect between Internet use and early adolescent externalizing problem behaviors.

Peer relationships as a mediator. Santrock (1998) defines peers as individuals who are similar in age, cognitive development, and maturity levels. Further elucidating the concept of peer relationships, Berk (1997) posits that it entails interactions among individuals of equal status, who possess shared capabilities and objectives. Complementing this notion, Zhou et al. (2015) articulate that a peer relationships encompasses interpersonal bonds forged and nurtured through interactions among individuals exhibiting analogous psychological development stages. Grounded in the ecosystem theory, the microsystem, encompassing entities such as family and schools, serves as a pivotal external determinant influencing individual psychological evolution (Zhou et al. 2015). Institutions of learning, succeeding family environments, emerge as the most consequential microsystems for adolescents (Eccles and Roeser 2011; Bronfenbrenner 1992).

Within this scholastic context, peer relationships, which constitute a primary interpersonal dynamic for adolescents, exert a significant influence on their holistic development (Crosnoe 2000; Giordano 2003; Crosnoe and Johnson 2011). This is particularly salient for Chinese adolescents, for whom educational settings not only serve as learning hubs but also pivotal living environments. Therefore, the role of interpersonal dynamics among peers stands as an indispensable component in the matrix of adolescent development factors (Ren et al. 2011; Zhang et al. 2013).

Attachment Theory (AT) offers an insightful framework for comprehending the mediating role of peer relationships in the relationship between Internet use and externalizing problem behaviors among early adolescents. At the heart of AT lies the principle that early emotional bonds, especially those with caregivers, profoundly shape an individual's social and emotional development (Bowlby 1969). During the transition from childhood to adulthood, peer relationships begin to play an increasingly significant role in adolescents' attachment networks, thereby influencing their developmental path (Savcı and Aysan 2016). In the realm of Internet usage, this developmental transition acquires additional complexity. The Internet serves as a medium for adolescents to establish and sustain peer relationships, presenting opportunities for positive social interactions as well as exposure to potentially harmful influences. Online interactions can either replicate or augment face-to-face relationships, thus affecting the nature of adolescents' social attachments (Reiner et al. 2017). Engaging in supportive and constructive online interactions with peers can promote the development of secure attachment styles, which are conducive to healthy emotional development and may act as a buffer against the onset of externalizing problem behaviors (Mónaco et al. 2019). Characteristics of secure attachments include enhanced self-esteem, improved emotional regulation, and more effective coping strategies (Savcı and Aysan 2016). In contrast, negative online externalizing problem behaviors, such as cyberbullying or engagement with risky behaviors, may lead to the formation of insecure attachment styles, frequently associated with externalizing problem behaviors (Ballarotto et al. 2018). These insecure attachments can manifest in the form of distrust, relationship anxiety, and challenges in emotion regulation, potentially intensifying tendencies towards aggressive, impulsive, or anti-social behaviors among adolescents (Gorrese 2016; Yaghoubipoor et al. 2019).

Empirical research has substantiated the principles of AT in the context of the interplay between Internet use, peer relationships, and externalizing problem behaviors. Peer relationships not only serve as indicators of intimacy and harmony among adolescents but also signify crucial elements of their socialization and primary metrics of social adaptation (Qian et al. 2021). Such relationships hold profound implications for adolescent behavioral development (Hartup 1992). Notably, peers act as astute detectors of problematic behaviors, with the quality of peer relationships significantly influencing the manifestation of these behaviors (Fowler et al. 2015). Members within peer cohorts often display congruence in addressing adaptive challenges, encompassing both externalized and internalized problem behaviors (Espelage et al. 2003; Hogue and Steinberg 1995; Kiesner et al. 2003). Elevated levels of peer acceptance can bolster an adolescent's motivation to assimilate prosocial behaviors from their cohorts (Barry and Wentzel, 2006). As a result, adolescents maintaining high-quality peer relationships are inclined to exhibit amplified prosocial tendencies (Carlo et al. 2012) and diminished problematic behaviors (Bao et al. 2015). Conversely, suboptimal peer relations can precipitate issues such as aggression and disciplinary infractions (Palmqvist and Santavirta 2006).

Implementing interventions targeting adolescent peer relationships can catalyze the enhancement of their prosocial behaviors (Yang et al. 2015).

Some scholars have posited that extensive use of the Internet may result in Internet addiction (Kuss and Lopez-Fernandez 2016; Kumar et al. 2019; Pontes et al. 2015). Adolescents with Internet addiction exhibit exacerbated relational challenges (Zhao et al. 2022). The peer relationships of these adolescents are often compromised, indicating a noticeable deficiency (Zhou and Fang 2015). Such individuals grapple with forming social connections (Paulus et al. 2018), frequently experiencing social isolation (Tateno et al. 2019). Their social competencies are diminished, and peer relationships are often characterized as inadequate (Zhou and Fang 2015; Chou et al. 2016). Consequently, adolescents with Internet addiction tendencies often maintain limited friendships, leading to heightened feelings of loneliness (Paulus et al. 2018; Ang et al. 2018). A strong association has been established between feelings of loneliness and excessive Internet usage (Tateno et al. 2019; Ang et al. 2018; Moretta and Buodo 2020; Weinstein et al. 2015). This suggests that the quality of peer relationships may be influenced, at least in part, by patterns of Internet consumption.

Regarding the mechanism among Internet use, peer relationships and early adolescent externalizing problem behaviors, peer relationships may possibly produce the intermediary effect between Internet use and early adolescent externalizing problem behaviors.

The chain mediating role of self-education expectation and peer relationships. Ecological Systems Theory (EST) offers a comprehensive framework for elucidating the indirect influence of Internet use on early adolescent externalizing problem behaviors through a chain-mediated effect involving self-education expectations and peer relationships. This theory posits that an individual's development occurs within a series of interconnected systems, extending from immediate environmental contexts to broader societal influences (Bronfenbrenner 1979).

Central to EST is the concept of the microsystem, which encompasses the direct environments with which an individual interacts. These environments include, but are not limited to, the family, school, and peer groups. Hong et al. (2017) emphasize that peer influence and school relationships are critical components of the microsystem in shaping the experiences of adolescents. An increase in self-education expectations signifies an adaptation within the microsystem. This adaptation has the potential to lead to changes in interactions with peers, another integral component of the microsystem, as discussed by Smith et al. (2016). Individuals with high self-education expectations often demonstrate increased motivation and engagement in academic pursuits. This can lead to positive effects on their peer relationships. Research by Wentzel and Watkins (2002) found that students who exhibit high academic self-expectations are more likely to participate actively in collaborative learning experiences and academic discussions. Engaging in these activities can foster a sense of camaraderie among peers, as they work together to achieve shared academic goals. On the other hand, overly high self-education expectations can lead to social isolation and peer alienation. Dweck and Leggett (1988) suggest that individuals with fixed mindsets, who believe that their abilities are fixed and unchangeable, may fear failure and avoid collaborative learning situations. Consequently, they might distance themselves from peers to protect their self-image, leading to strained relationships and social withdrawal.

Furthermore, the mesosystem, as conceptualized by Bronfenbrenner, which denotes the interconnections between various

microsystems, is instrumental in this context. The interplay between an adolescent's Internet use (a component of their microsystem) and their peer relationships (another microsystem) is pivotal. O'Neill (2015) discusses the complexity of interactions between young Internet users and their microsystems, highlighting how Internet use can shape these interactions. Positive alterations within one microsystem, such as enhanced self-education expectations due to Internet usage, can have a beneficial impact on other microsystems, like peer dynamics, thereby indirectly shaping adolescent behavior.

Following the earlier discourse, one may deduce the existence of a linkage between Internet use and self-education expectation, a connection between self-education expectation and peer relationships, and an additional connection between peer relationships and early adolescent externalizing problem behaviors. Thus, it is conceivable that Internet use could indirectly affect early adolescent externalizing problem behaviors through a sequential mediation involving self-education expectation and peer relationships.

Gender heterogeneity. Subrahmanyam et al. (2001) observed a gender disparity in Internet usage, with 58% of boys using the Internet more frequently than their female counterparts, who stood at 44%. A subsequent study focusing on the risk associated with Chinese youth's engagement on Internet platforms reported, from a sample of 126 cases, that male adolescents constituted 70.85% of the sample, outnumbering female adolescents by a factor of 2.3. Distinct variations in Internet risk behavior were evident across genders. Male adolescents displayed a diverse range of risk behaviors, spanning from excessive online consumption to severe breaches of law. In contrast, female adolescents predominantly engaged in over-consumption and online social networking, presenting a comparatively lower risk profile (China Youth New Media Association, School of Journalism & Tsinghua University, 2020). Li et al. (2010) posited that female adolescents, due to their earlier maturation and enhanced self-regulatory capabilities, might employ these traits to sidestep prolonged Internet usage. Moreover, gender-based disparities in personality traits suggest that female adolescents typically exhibit amicability, superior emotional intelligence, and advanced social skills (Schmitt et al. 2008). Such attributes could empower them to address real-life challenges more effectively, reducing the allure of excessive Internet immersion. On the other hand, male adolescents manifest a heightened prevalence of externalizing problem behaviors, such as smoking (Chi and Cui 2020), alcohol consumption (Fite et al. 2006; Kendler et al. 2011), and gambling (Giannotta et al. 2022; Richard and Derevensky 2017). This susceptibility extends to Internet addiction, with male adolescents being more vulnerable than their female counterparts (Su et al. 2019). Consequently, the impact of Internet usage on early adolescent externalizing problem behaviors might display variations that are specific to gender.

Urban-rural heterogeneity. Distinct disparities in economic income, educational access, social security, relational networks, and lifestyles characterize the urban and rural populace. Rooted in the urban-rural dichotomy, these objective variances in social attributes have engendered divergent subjective attitudes and perceptions among urban and rural inhabitants (Fan and Hong 2015). The 2020 national survey on minors' Internet engagement underscores that, although disparities in Internet accessibility between urban and rural minors have largely been bridged, distinct differences persist in their online activities. Specifically, urban minors predominantly utilize the Internet for information retrieval and interpersonal communication, while their rural

counterparts frequently restrict their online engagement to entertainment (The Youth Rights, Interests Protection Department of the Communist Youth League Central Committee & China Internet Network Information Center, 2021). Consequently, the implications of Internet usage on early adolescent externalizing problem behaviors may be modulated by the urban and rural residential frameworks, manifesting distinct outcomes in these two settings.

The present study. The role of Internet usage in the developmental trajectory of early adolescents has garnered significant scholarly interest. While an array of studies has emerged globally, there remains a paucity of research dedicated to Chinese early adolescents, especially concerning the ramifications of Internet usage on their externalizing problem behaviors. Notably, extant literature often fixates on a singular association, neglecting the multifaceted interplay of several determinants. Recognizing the developmental nuances of early adolescence—a period marked by considerable flux and transition—it becomes evident that externalizing problem behaviors are shaped by a myriad of factors, ranging from the broader social milieu to individual intrinsic characteristics. Drawing on the principles of Social Learning Theory, Self-Determination Theory, Attachment Theory, and Ecological Systems Theory, the Internet is identified as a salient component of the contemporary social landscape that inevitably influences early adolescent behaviors. Central to this developmental phase are the constructs of self-education expectations and peer relationships, both of which serve as foundational pillars in guiding adolescents towards adaptive behavioral patterns. Thus, the potential influence of the Internet on these constructs suggests an indirect pathway through which Internet usage may shape early adolescent externalizing problem behaviors. Specifically, self-education expectations and peer relationships might mediate this relationship. Moreover, considering the pronounced socio-demographic disparities, such as gender and urban-rural dichotomies, the interrelationship between Internet usage and early adolescent externalizing problem behaviors may exhibit nuanced variations across these demographic axes.

To this end, we propose the hypotheses from H1 to H6 (See Fig. 1):

Hypothesis 1 (H1). The longer the Internet is used, the higher the incidence rate of early adolescent externalizing problem behaviors.

Hypothesis 2 (H2). Self-education expectation serves as a mediator in the association between Internet use and early adolescent externalizing problem behaviors.

Hypothesis 3 (H3). Peer relationships serves as a mediator in the association between Internet use and early adolescent externalizing problem behaviors.

Hypothesis 4 (H4). Self-education expectation and peer relationships demonstrate a sequential mediating effect on the link between Internet use and early adolescent externalizing problem behaviors.

Hypothesis 5 (H5). The impact of Internet use on early adolescent externalizing problem behaviors has gender-related differences.

Hypothesis 6 (H6). The impact of Internet use on early adolescent externalizing problem behaviors has urban-rural differences.

Materials and methods

Participants. A total of 1191 individuals were included in the study, selected from three junior high schools and three primary schools in three different provinces in China (Liaoning, Henan, and Sichuan). The participants were recruited using a

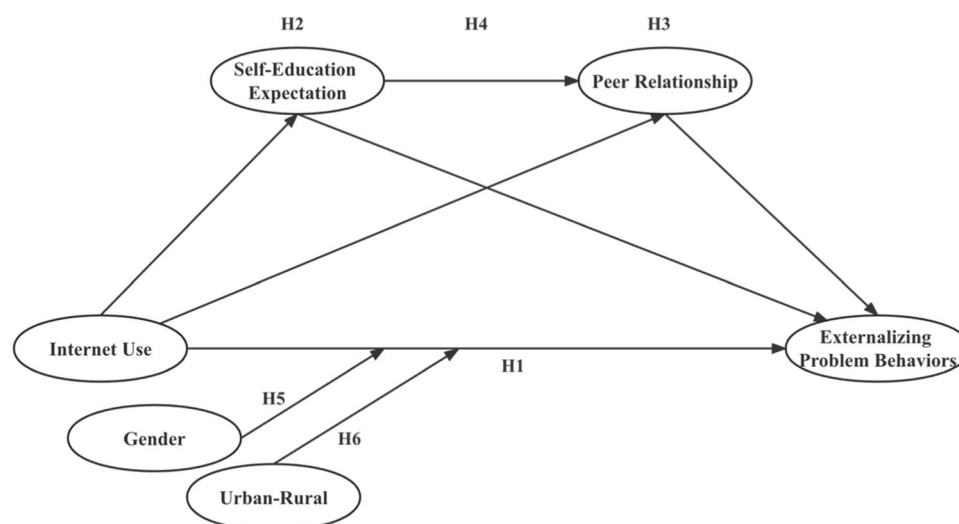


Fig. 1 A hypothesized mediation model. Hypothesis 1 (H1). The longer the Internet is used, the higher the incidence rate of early adolescent externalizing problem behaviors. Hypothesis 2 (H2). Self-education expectation serves as a mediator in the association between Internet use and early adolescent externalizing problem behaviors. Hypothesis 3 (H3). Peer relationships serves as a mediator in the association between Internet use and early adolescent externalizing problem behaviors. Hypothesis 4 (H4). Self-education expectation and peer relationships demonstrate a sequential mediating effect on the link between Internet use and early adolescent externalizing problem behaviors. Hypothesis 5 (H5). The impact of Internet use on early adolescent externalizing problem behaviors has gender-related differences. Hypothesis 6 (H6). The impact of Internet use on early adolescent externalizing problem behaviors has urban-rural differences.

combination of stratified and random cluster sampling techniques. The data collection took place in March 2023, after obtaining permission from the schools and obtaining written informed consent from both the participants and their guardians. The informed consent form ensured anonymity and confidentiality, without requiring a signature or the student's name. Participants were informed about the voluntary nature of their participation and their right to withdraw from the study at any time. Trained research assistants guided the students who agreed to participate in completing a pencil and paper questionnaire independently during regular school hours. The completed questionnaires were sealed in envelopes. As a token of appreciation, a small gift such as a pen or a card was offered to the participants. After excluding 36 questionnaires with significant missing information, a total of 1155 valid questionnaires were included in the analysis, resulting in a response rate of 97%. The age of the participants ranged from 11 to 14 years, with an average age of 12.36 years ($SD = 0.553$). Among the participants, 48.2% ($N = 557$) were boys and 51.8% ($N = 598$) were girls. Additionally, 44.9% ($N = 519$) of the participants resided in rural areas, while 55.1% ($N = 636$) were from urban areas. The research materials used in this study underwent review and approval by the research ethics committee at the first author's university.

Measures. Externalizing problem behaviors. Externalizing problem behaviors were assessed using the Youth Self-Report (YSR; Achenbach 1991a, b). This instrument has been validated and demonstrated reliability in preceding studies (Feng and Lan 2020; Yang and Zhu 2023). The YSR Externalizing Problem Behavior Scale is bifurcated into two subscales: the Aggressive Behavior and the Rule-Breaking Behavior. Both subscales encompass 15 items each, resulting in a comprehensive 30-item assessment. A representative item is "I destroy my own belongings." Responses were structured on a 3-point Likert scale, with 1 signifying "not true", 2 denoting "somewhat true", and 3 indicating "very true". Aggregate scores were derived by computing the mean of all items; an elevated score typifies a pronounced level of externalizing problem behaviors in early adolescents. The instrument

also showcased strong internal consistency, as indicated by a Cronbach's alpha value of 0.930.

Internet use. Internet use was assessed by asking early adolescents to report the average amount of time they spent online on weekdays and weekends. This measurement was conducted using a six-point scale, with two specific questions: "How many hours, on average, do you spend on the Internet on weekdays?" and "How many hours, on average, do you spend on the Internet on weekends?". The scale ranges from 1 (less than 30 min) to 6 (more than 4 h). To calculate the total score for Internet use, the score for weekdays was multiplied by 5 and the score for weekends was multiplied by 2. These two scores were then added together and divided by 7 to represent the amount of Internet use by early adolescents. This measure has been shown to be reliable and valid in previous studies (Ren and Zhu 2022).

Self-education expectation. Self-education expectation was measured by the question "What education level would you like to be equipped with?". The following scores were assigned to each response: 1 = drop out of school now, 2 = junior high school, 3 = technical secondary school/technical school, 4 = vocational high school, 5 = ordinary high school, 6 = junior college, 7 = bachelor's degree, 8 = master's degree, and 9 = PhD. This measure has been shown to be reliable and valid in previous studies (Li et al. 2020; Li and Hu 2021).

Peer relationships. The assessment of peer relationships was conducted using the 8-item PROMIS Pediatric Peer Relationships Scale (DeWalt et al. 2013). This scale has previously exhibited robust psychometric properties among Chinese early adolescents (Huang et al. 2021). Sample items include: "I was able to rely on my friends" and "I felt accepted by peers of my age group." Responses were captured using a 5-point Likert scale, where 1 signifies 'never' and 5 denotes 'almost always.' An aggregate score was determined by calculating the mean of all items; a higher composite score suggests better peer relationships. Additionally, the scale demonstrated commendable internal consistency, evidenced by a Cronbach's alpha value of 0.887.

Table 1 Measurement instructions for variables.

Variables	Variable description	Mean	SD
Core variables			
Externalizing problem behaviors	Continuous variable	1.373	0.315
Internet use	Continuous variable	2.344	1.210
Self-education expectation	1 = drop out of school now, 2 = junior high school, 3 = technical secondary school/technical school, 4 = vocational high school, 5 = ordinary high school, 6 = junior college, 7 = bachelor's degree, 8 = master's degree, and 9 = PhD	7.010	1.460
Peer relationships	Continuous variable	3.935	0.857
Control variables			
Family's book collection	1 = few, 2 = relatively few, 3 = average, 4 = relatively many, and 5 = many	3.300	1.057
Father's level of education	1 = no education, 2 = primary school, 3 = junior high school, 4 = technical secondary school/technical school, 5 = vocational high school, 6 = ordinary high school, 7 = junior college, 8 = bachelor's degree, and 9 = master's degree and above	4.667	2.018
Mother's level of education	1 = no education, 2 = primary school, 3 = junior high school, 4 = technical secondary school/technical school, 5 = vocational high school, 6 = ordinary high school, 7 = junior college, 8 = bachelor's degree, and 9 = master's degree and above	4.543	2.076
Parental expectations of education	1 = drop out of school now, 2 = junior high school, 3 = technical secondary school/technical school, 4 = vocational high school, 5 = ordinary high school, 6 = junior college, 7 = bachelor's degree, 8 = master's degree, and 9 = PhD	7.069	1.445
Family's economic conditions	1 = very difficult, 2 = relatively difficult, 3 = medium, 4 = relatively rich, and 5 = best	2.916	0.565
Gender	0 = female ; 1 = male	0.482	0.500
Nationality	0 = Ethnic minority; 1 = Han ethnicity	0.950	0.218
Age	Continuous variable (unit: year)	12.357	0.553
Household registration	0 = urban; 1 = rural	0.449	0.498
Physical health condition	1 = very poor, 2 = relatively poor, 3 = medium, 4 = relatively good, and 5 = best	3.916	0.924

Control variables. Drawing on prior research (Zhu et al. 2023; Zhang et al. 2021), two types of control variables pertinent to early adolescent externalizing problem behaviors were identified.

Family characteristics. Attributes of familial environments encompass not only the extent of the family's library but also the educational backgrounds of the father and mother, the academic aspirations parents hold for their offspring, and the family's financial standing. In assessing the breadth of the family's collection of books, respondents were queried with, "Does your household possess a considerable number of books (excluding textbooks and periodicals)?" leading to a classification of answers into five distinct groups. The scoring for responses across various categories was assigned as follows: 1 signifying few, to 5 representing many. Regarding inquiries about "The educational attainment of your father" and "The educational attainment of your mother," the answers were categorized and scored on a scale from 1, representing no formal education, to 9, signifying a master's degree or higher, with intermediate values reflecting ascending levels of educational achievement, from primary education through to bachelor's degrees. Concerning parental expectations for their children's education, encapsulated by the query, "To what educational level do your parents aspire for you?" responses were delineated into nine segments. The valuation of responses for this dimension ranged from 1, advocating for immediate school withdrawal, to 9, aiming for a doctoral degree, with intermediate scores reflecting progressively higher educational benchmarks. The family's economic status was gauged by asking, "How would you describe your family's current financial situation?" with responses stratified on a scale from 1, indicating severe financial hardship, to 5, denoting the highest level of economic prosperity.

Individual characteristics. We account for the personal attributes of the early adolescent, encompassing gender, nationality, chronological age, the nature of household registration (either urban or rural), and the state of physical well-being. (See Table 1).

Statistical analysis. SPSS Version 23.0, STATA Version 16.0 and MPLUS Version 8.3 were used for data analysis.

First, we used Harman's one-way method to test for the presence of common method bias.

Second, descriptive statistics and bivariate correlations were used to assess the relationship among core variables.

Third, when analyzing the impact of Internet use on early adolescent externalizing problem behaviors, the method of gradually increasing influencing factors was used for the ordinary least squares (OLS) regression results. The OLS regression analysis was conducted in this process using a stepwise increase in the number of influencing factors, with the model formula:

$$CA_i = \beta_0 + \beta_1 \rho_i + \sum_{k=1}^k \beta_k x_{ik} + \varepsilon_i \quad (1)$$

where CA_i represents the score of the externalizing problem behaviors, ρ_i represents the score of the Internet use, x_{ik} represents the control variable, β_0 is the intercept term, β_1 is the coefficient of ρ_i for the Internet use, β_k is the coefficient of the control variable x_{ik} , and ε_i is the error term (Li et al. 2023; Zhu et al. 2023).

Fourth, utilizing the Generalized Propensity Score Matching Model (GPSM), this study aims to further investigate the relationship between Internet use and externalizing problem behaviors. Additionally, the GPSM estimates will be utilized to conduct robustness tests for the OLS method. And the robustness of OLS was tested based on the estimation of GPSM with the model equation:

$$E(Y_i | T_i, \hat{\mathcal{R}}_i) = \alpha_0 + \alpha_1 T_i + \alpha_2 \hat{\mathcal{R}}_i + \alpha_3 T_i \hat{\mathcal{R}}_i \quad (2)$$

where the treatment variable T is Internet use and the outcome variable Y is externalizing problem behaviors. Initially, the conditional probability density distribution of the treatment variable T is estimated by GPSM based on the given covariates X , and the generalised propensity score \mathcal{R} is obtained. Therefore, the two factors that affect both the treatment variable and the outcome variable: the early adolescent and the family are selected as covariates. Then, by constructing an OLS regression model

Table 2 Correlation analysis between key variables.				
	Externalizing problem behaviors	Internet use	Self-education expectation	Peer relationships
Externalizing problem behaviors	-			
Internet use	0.233***	-		
Self-education expectation	-0.245***	-0.220***	-	
Peer relationships	-0.361***	-0.123***	0.166***	-
*** $p < 0.01$.				

Table 3 Ordinary least squares benchmark regression results for the effect of Internet use on early adolescent externalizing problem behaviors.			
Variables	(1) Externalizing problem behaviors	(2) Externalizing problem behaviors	(3) Externalizing problem behaviors
Internet Use	0.061*** (0.009)	0.057*** (0.009)	0.044*** (0.008)
Family's book collection		-0.027*** (0.010)	-0.012 (0.009)
Father's educational level		0.002 (0.006)	0.001 (0.006)
Mother's educational level		-0.010* (0.006)	-0.002 (0.005)
Parental educational expectations		-0.020*** (0.007)	-0.015** (0.007)
Family economic conditions		0.028 (0.018)	0.008 (0.015)
Age			-0.000 (0.015)
Gender			0.282*** (0.016)
Nationality			0.029*** (0.029)
Household registration			0.055*** (0.019)
Physical health condition			-0.043*** (0.009)
Sample size	1155	1155	1155
R ²	0.054	0.089	0.310
The robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.			

with the treatment variable T and the generalised propensity score \mathcal{R} , the conditional expectation of the outcome variable Y was calculated and the coefficients $\alpha_0 \sim \alpha_3$ were obtained. Ultimately, the range of values of the treatment variable T was divided into a number of equally spaced consecutive intervals, and based on the α coefficients obtained in the previous step, the average treatment effect (ATE) of T was estimated within each interval (Chen et al. 2014; Li et al. 2023).

Fifth, structural equation modeling was utilized to investigate the proposed model of chain mediation. Within this framework, Internet use was designated as the predictor variable, while self-education expectation and peer relationships functioned as mediators. The outcome variable of focus was externalizing problem behaviors. Mediation was confirmed if the 95% confidence interval (CI) for the indirect effect excluded zero. To determine the significance of the indirect effects, bootstrapped confidence intervals (CIs) were employed, derived from 5000 bootstrap samples.

Finally, the samples were divided by gender and registered residence of the early adolescent, and the significance of the heterogeneity was examined using a Fisher permutation test (Li et al. 2023; Zhu et al. 2023).

Results

Common method bias test. To ascertain the potential for common method bias, Harman's single-factor test was employed, as delineated by Zhou and Long (2004). An exploratory factor analysis yielded 14 factors, each with eigenvalues exceeding 1. The predominant factor accounted for 30.002% of the total variance, which is notably below the often-referenced threshold of 40%. This suggests that common method bias is not a significant concern in this dataset, allowing for subsequent data analyses.

Correlation analysis of variables. To examine the relationships between the primary variables, Pearson correlation analysis was employed. Table 2 provides a comprehensive overview, detailing the means, standard deviations (SDs), and Pearson correlation coefficients for these central variables. Notably, all primary variables exhibited significant correlations. Specifically, externalizing problem behaviors showed a positive correlation with Internet use ($r = 0.233, p < 0.01$) and negative correlations with both self-education expectation ($r = -0.245, p < 0.01$) and peer relationships ($r = -0.220, p < 0.01$). Internet use also exhibited negative associations with self-education expectation ($r = -0.361, p < 0.01$) and peer relationships ($r = -0.123, p < 0.01$). Additionally, a positive correlation was observed between self-education expectation and peer relationships ($r = 0.166, p < 0.01$).

OLS regression results. Table 3 delineates the association between the duration of Internet use and the occurrence of externalizing problem behaviors in early adolescents. The analysis comprised three distinct models: Model (1) exclusively examines the independent variable, Internet use. Model (2) incorporates family characteristic variables in addition to the parameters of Model (1). Model (3) expands upon Model (2) by also including variables pertaining to early adolescent individual characteristics. Within Table 3, the estimated coefficients for Internet use across Models (1) to (3) were 0.061 ($p < 0.01$), 0.057 ($p < 0.01$), and 0.044 ($p < 0.01$), respectively. All coefficients were statistically significant at the 1% level, underscoring a positive predictive association between Internet use and the emergence of externalizing problem behaviors among early adolescents.

Robust test based on the GPSM. The Dose-Response Function plot (Fig. 2) for the instrumental variable demonstrated that, after matching through the GPSM method, there was a significant

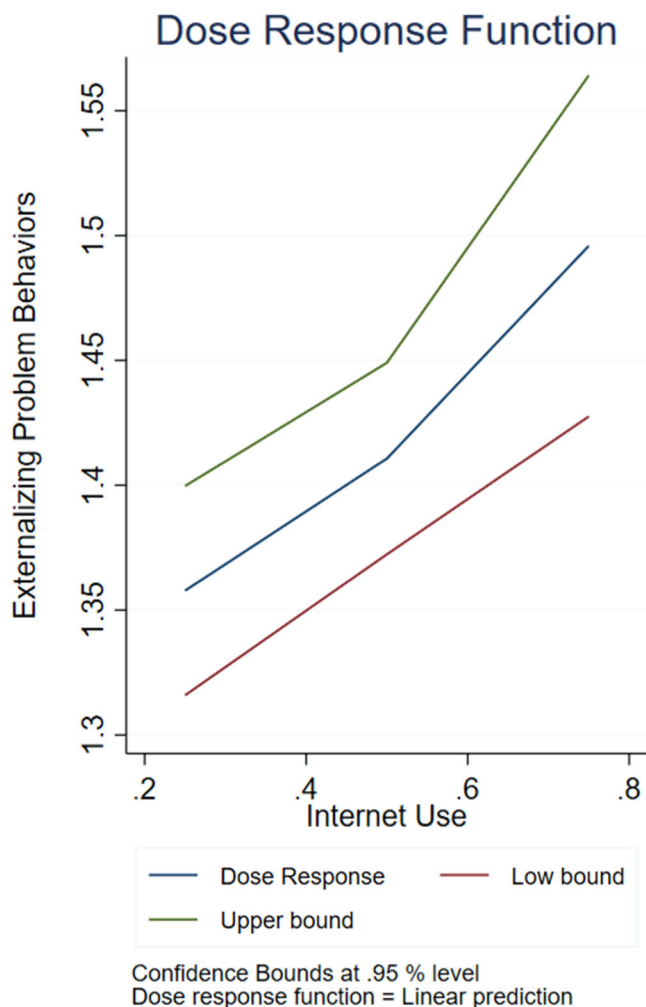


Fig. 2 Dose response function graph based on GPSM estimation. The dose-response curve (blue) illustrates the predicted change in externalizing problem behaviors as a function of internet use. The lower and upper bounds (red and green, respectively) represent the 95% confidence intervals, indicating the range within which we can be 95% certain that the true dose-response relationship lies. This model assumes a linear prediction for the dose-response function. Internet use is measured on the horizontal axis, while the externalizing problem behaviors are quantified on the vertical axis.

concurrent rise in early adolescent externalizing problem behaviors accompanying an escalation in Internet use. Moreover, the positive correlation between Internet use and externalizing problem behaviors remained statistically significant, indicating that Internet use has a substantial positive impact on externalizing problem behaviors. This consistency with the earlier OLS regression findings suggests that the effect of Internet use on early adolescent externalizing problem behaviors is robust.

Mediation analysis. Mean values for the examined variables were computed, following which a structural equation model (SEM) was established. The derived Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) both registered optimal values of 1. Concurrently, the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR) achieved values of zero. Such indices typically infer a commendable predictive validity of the research model. Consequently, a chain mediation model was assessed encompassing three indirect effects: (1) Self-education expectation functioned as a mediator in the connection between Internet use and externalizing problem behaviors among early adolescents; (2) Peer relationships acted as mediators in the linkage between Internet use and early adolescents' externalizing problem behaviors; and (3) Self-education expectation and peer relationships exhibited a chain mediational effect in associating early adolescents' Internet use with their externalizing problem behaviors (Fig. 3).

The findings revealed that Internet use and externalizing problem behaviors demonstrated significant and positive correlations ($\beta = 0.061$, $t = 8.135$, $p < 0.01$). Even when accounting for the effects of control variables, the direct relationship between Internet use and externalizing problem behaviors persisted as significant and positive ($\beta = 0.159$, $t = 5.667$, $p < 0.01$). Additionally, Internet use was found to be significantly and negatively linked to self-education expectation ($\beta = -0.220$, $t = -7.302$, $p < 0.01$), and self-education expectation was significantly and negatively associated with externalizing problem behaviors ($\beta = -0.158$, $t = -5.595$, $p < 0.01$). Furthermore, a significant and negative association was observed between Internet use and peer relationships ($\beta = -0.091$, $t = -3.006$, $p < 0.01$), with peer relationships also showing a significant and negative impact on externalizing problem behaviors ($\beta = -0.315$, $t = -12.295$, $p < 0.01$). Lastly, a significant and positive relationship was identified between self-education expectation and peer relationships ($\beta = 0.146$, $t = 4.700$, $p < 0.01$).

Moreover, as illustrated in Table 4, the total effect of Internet use on externalizing problem behaviors was quantified at 0.233

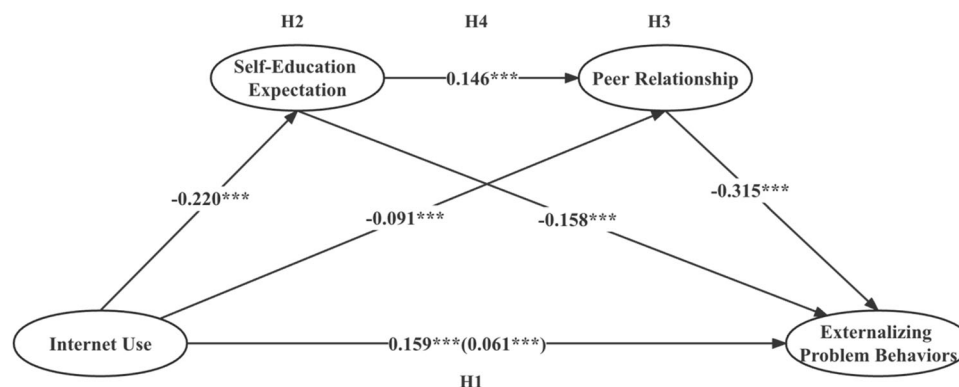


Fig. 3 Results from path analysis on the research hypothesis model. Pathways between variables are indicated by standardized beta estimates; →Significant path; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 Direct, indirect, and total effects of the hypothesized model.				
Model pathways	Estimated effect (β)	Boot SE	95% CI	
			Lower	Upper
Direct effect				
Internet use→Externalizing problem behaviors	0.159***	0.028	0.103	0.213
Indirect effects				
Internet use→Self-education expectation→Externalizing problem behaviors	0.035***	0.008	0.020	0.053
Internet use →Peer relationships→Externalizing problem behaviors	0.029***	0.010	0.010	0.048
Internet use→Self-education expectation→Peer relationships→Externalizing problem behaviors	0.010***	0.003	0.006	0.016
Total effect	0.233***	0.031	0.170	0.292

*** $p < 0.01$.

Table 5 Impact of Internet use on early adolescent externalizing problem behaviors: gender-related differences.		
Variables	(1) Externalizing problem behaviors	(2) Externalizing problem behaviors
	Male	Female
Internet use	0.058*** (0.012)	0.025** (0.010)
Control variable	yes	yes
Sample size	557	598
R ²	0.127	0.081
Fisher empirical p value	0.025**	

The robust standard errors are in parentheses. The Fisher empirical p value is used to test the significance of the coefficient difference between the groups, which was obtained by 5000 self-sampling times.

** $p < 0.05$; *** $p < 0.01$.

($SE = 0.031$, 95% CI [0.170, 0.292], $p < 0.01$), with a direct effect of 0.159 ($SE = 0.028$, 95% CI [0.103, 0.213], $p < 0.01$), indicating statistical significance for both the total and direct effects. The indirect effect along the pathway from Internet use to self-education expectation to externalizing problem behaviors was 0.035 ($SE = 0.008$, 95% CI [0.020, 0.053], $p < 0.01$), accounting for 15.021% of the total effect of 0.233. Additionally, the indirect effect in the pathway from Internet use to peer relationships to externalizing problem behaviors was 0.029 ($SE = 0.010$, 95% CI [0.010, 0.048], $p < 0.01$), constituting 12.446% of the total effect. A further indirect effect of 0.010 ($SE = 0.003$, 95% CI [0.006, 0.016], $p < 0.01$) was noted in the pathway from Internet use through self-education expectation to peer relationships and then to externalizing problem behaviors, representing 4.292% of the total effect. The Bootstrap 95% confidence intervals for these indirect effects did not include zero, confirming their statistical significance. The analysis demonstrated that the indirect influences of Internet use on externalizing problem behaviors depend on the roles of self-education expectation and peer relationships, which act as significant and negative partial mediators in this relationship.

Heterogeneity results

Analysis of gender-related differences. Table 5 delineates gender-specific differences regarding the influence of Internet use on early adolescent externalizing problem behaviors after accounting for control variables. Specifically, Models (1) and (2) respectively depict the effects of Internet use on externalizing problem behaviors for male and female early adolescents. Both models achieved significance at the 1% level. The regression coefficient quantifying the effect of Internet use on male early adolescent

Table 6 Impact of Internet use on early adolescent externalizing problem behaviors: urban-rural differences.		
Variables	(1) Externalizing problem behaviors	(2) Externalizing problem behaviors
	Urban	Rural
Internet use	0.033*** (0.010)	0.057*** (0.013)
Control variable	yes	yes
Sample size	636	519
R ²	0.288	0.318
Fisher empirical p value	0.062*	

The robust standard errors are in parentheses. The Fisher empirical p value is used to test the significance of the coefficient difference between the groups, which was obtained by 5000 self-sampling times.

* $p < 0.1$; *** $p < 0.01$.

externalizing problem behaviors was 0.058, exceeding the equivalent figure for female early adolescents, which was 0.025. Additionally, the empirical p -value obtained from the Fisher test, which evaluated the difference in coefficients between genders regarding the impact of Internet use on early adolescent externalizing problem behaviors, reached statistical significance at the 5% level.

Analysis of urban-rural differences. Table 6 delineates the variations between urban and rural settings concerning the impact of Internet use on early adolescent externalizing problem behaviors, with adjustments for control variables incorporated. Models (1) and (2) depict the effects of Internet use on externalizing problem behaviors among urban and rural early adolescents, respectively, with both models attaining statistical significance at the 1% level. Notably, the regression coefficient for the influence of Internet use on rural early adolescent externalizing problem behaviors was 0.057, surpassing the analogous coefficient for urban early adolescents, recorded at 0.033. Additionally, the empirical p -value derived from the Fisher test, which assessed the difference in coefficients between urban and rural contexts in relation to the influence of Internet use on early adolescent externalizing problem behaviors, reached statistical significance at the 10% level.

Discussion

Internet use increases the risk of externalizing problem behaviors in early adolescents. Internet use plays a pivotal role in shaping the behavioral trajectories of early adolescents. This study reveals that prolonged Internet use significantly correlates with the emergence of externalizing problem behaviors during early adolescence. Our findings fortify the primary hypothesis (H1), illustrating the detrimental influences of the Internet on the

behavioral development of adolescents. In comparing our findings with extant literature, both similarities and disparities are evident. Research conducted by Hou et al. (2024), for instance, has similarly identified a relationship between heightened screen time and the prevalence of externalizing behaviors in adolescent populations. Our study, however, augments these findings by specifically targeting early adolescents and by explicating the range of externalizing behaviors influenced by internet usage. Furthermore, our findings are consistent with the observations reported by Cerruti et al. (2017) and Martins et al. (2020), thus strengthening the notion that prolonged internet usage can serve as a potential minefield of behavioral pitfalls for adolescents who are either unaware or inadequately supervised. A plausible explanation for these findings is that prolonged exposure to the Internet increases the probability of adolescents encountering undesirable content and experiences. Such encounters may potentially distort their behavioral norms (Guan 2013; Liu and Gao 2013; Yu 2020). It's imperative to recognize the dual-faceted nature of the Internet. On one side, it's a reservoir of advantageous resources, such as educational web pages and games designed specifically for this age group (Holtz and Appel 2011). Conversely, the web is also inundated with deleterious content such as age-inappropriate materials, violent video games, and unsupervised chat spaces (Donnerstein et al. 2009; Funk 2009). Another possible explanation is that prolonged exposure to a virtual environment, which lacks immediate tangible repercussions, may lead to desensitization among young users regarding the consequences of their actions. This could potentially increase the prevalence of externalizing behaviors in real-life situations. This phenomenon encapsulates the concept that the virtual social milieu may inadvertently instruct adolescents to prioritize aggressive or inappropriate behaviors over prosocial ones (Marsh et al. 2024). In a divergent vein, the study by Fasihi and Rostami (2023) reported only a moderate correlation between internet use and externalizing behaviors, placing a greater emphasis on internalizing issues such as anxiety and depression. The divergence between their findings and ours may be ascribed to variations in sample demographics, the instruments used for measurement, or differing patterns of internet use. In conclusion, our study contributes to the expanding corpus of literature that illuminates the developmental susceptibilities of early adolescents in the digital era. As elucidated by Telzer et al. (2023), this demographic is notably prone to external influences, rendering the insights from this study pivotal in comprehending how digital interactions can mold behavioral patterns (Armstrong-Carter and Telzer 2022).

The mediating effect of self-education expectation and peer relationships between Internet use and externalizing problem behaviors in early adolescents. The second hypothesis (H2) of this study has been empirically confirmed, identifying self-education expectation as the mediating mechanism by which Internet use affects the emergence of externalizing problem behaviors in early adolescents. Internet use has the potential to diminish self-education expectation in early adolescents, thereby elevating the incidence of their externalizing problem behaviors. One possible reason for the undermining of self-education expectations among early adolescents is the prevalence of distractions caused by the internet. Constant exposure to social media, online games, and other entertainment platforms can lead to reduced attention spans, making it challenging for adolescents to focus on educational pursuits (Gazzaley and Rosen 2016). This lack of concentration might deter them from engaging in self-directed learning, leading to a decline in their overall academic motivation. Additionally, for some adolescents, excessive internet

use might serve as a form of escapism from academic pressures or personal issues (Kuss and Griffiths 2017). When faced with challenging educational tasks or stress, they may resort to online activities as a coping mechanism, neglecting their self-education expectations in the process. This escape-oriented behavior can further reinforce externalizing problem behaviors as an outlet for emotional distress. This observation becomes particularly salient when contrasted with existing research that underscores the educational potential of the Internet (Adiyono et al. 2024). Our study underscores the criticality of the nature of Internet engagement; it posits that unstructured or unsupervised Internet usage might undermine educational aspirations, which is congruent with the findings of Twenge et al. (2019). Furthermore, the observed negative correlation between Internet use and self-education expectation in our study resonates with the apprehensions articulated by Lin et al. (2024) regarding the potential of digital technologies to divert and detach young users from academic and educational endeavors. However, diverging from these studies that predominantly concentrate on screen time, our research probes into the more profound psychological implications, revealing how Internet usage can subtly alter adolescents' attitudes towards self-motivated learning.

The present research validates the third hypothesis (H3) positing that peer relationships act as a mediating variable in elucidating the correlation between Internet use and the manifestation of externalizing problem behaviors among early adolescents. Early adolescents engaging in protracted Internet use are potentially more susceptible to challenges in their peer relationships. Subsequently, these challenges augment the propensity to demonstrate externalizing problem behaviors. Peer relationships significantly influence the behavioral and social development of adolescents (Dishion and Tipsord 2011). Typically, adolescents pursue validation, acceptance, and social sustenance from their peer groups (Shao and Kang 2022). Prolonged Internet usage might hinder the establishment of robust peer relationships; an overextension of time online could curtail direct social engagement, thereby affecting interpersonal skills (Kraut et al. 1998). Such social detachment, coupled with a deficit in social aptitude, can heighten the risk for externalizing problem behaviors (Prinstein and Dodge 2008). This observation is particularly noteworthy in light of existing research that underscores the pivotal role of peer relationships in adolescent development (Mitic et al. 2021). Our study aligns with these perspectives but delves deeper into how Internet use can potentially disrupt these critical social connections, thereby exacerbating externalizing behaviors such as aggression, rule-breaking, and social defiance. This relationship underscores the findings of Cui et al. (2023), who noted the impact of digital communication on adolescent social skills and peer interactions. Furthermore, the impact of Internet use on the quality of peer relationships among early adolescents echoes concerns highlighted in previous studies (e.g., Kar and Arafat 2023), which suggested that excessive and unstructured online engagement could lead to social isolation and diminished interpersonal skills. However, our research expands upon these findings by illustrating the direct link between such disrupted peer relationships and the increase in externalizing problem behaviors. Additionally, our study contributes to the growing body of literature that emphasizes the vulnerability of early adolescents to external influences, especially in the context of their online interactions (Newson et al. 2024). Understanding the nuanced impact of Internet use on peer relationships provides critical insights into how digital behavior influences broader behavioral patterns among adolescents.

This study demonstrates the sequential mediating role of self-education expectation and peer relationships in the connection

between Internet use and externalizing problem behaviors among early adolescents (H4). Specifically, higher levels of Internet use in early adolescents tend to correlate with increased externalizing problem behaviors, mediated through reduced self-education expectation and weaker peer relationships. When individuals have high self-education expectations, they tend to be more proactive in seeking knowledge and learning opportunities. This active pursuit of knowledge can lead to a wealth of information and insights that individuals can share with their peers. Engaging in discussions, debates, and group studies on various educational topics creates a positive and collaborative learning environment among peers, fostering strong bonds and mutual respect (Johnson and Johnson 2009). Furthermore, individuals with high self-education expectations often serve as inspirational role models for their peers. They demonstrate a strong commitment to learning, continuous self-improvement, and goal-oriented behavior. Peers are likely to be influenced positively by their example, leading to increased motivation and aspirations for their own self-education (DeLay et al. 2016). As a result, this shared pursuit of academic excellence can strengthen peer relationships through mutual encouragement and support. Therefore, the influence of self-education expectation and peer relationships outcomes cannot be understated.

The results of this study offer a nuanced understanding of the implications of Internet use on early adolescent behavior, thereby enriching the comprehension of principles associated with early adolescent development. These findings augment extant theories regarding early adolescent behavior and can serve as a foundational reference to foster positive behavioral trajectories in this age group. Moreover, the study underscores the significance of self-educational expectations as elucidated by Wu and Huang (2016), Yang (2018), and Fan and Wolters (2014), and the pivotal role of peer relationships as highlighted by Qian et al. (2021), Fowler et al. (2015), and Bao et al. (2015).

The gender heterogeneity between Internet use and externalizing problem behaviors in early adolescents. The results of the study indicate a substantial influence of Internet use on the externalizing problem behaviors of both male and female early adolescents. Notably, there exists a discernible disparity between genders, corroborating the fifth hypothesis (H5). Furthermore, male early adolescents exhibit a more pronounced susceptibility to the adverse effects of Internet use on externalizing problem behaviors compared to their female counterparts. A plausible explanation for this phenomenon is the hypothesis proposed by Twenge and Martin (2020), suggesting that patterns of Internet usage significantly differ between male and female adolescents. Their findings indicate that males tend to access the Internet more frequently and across a broader range of domains. One potential rationale for this discrepancy is the greater technological affinity observed in males (Wajcman 2000). Elevated Internet engagement heightens the likelihood of excessive use, culminating in pronounced ramifications. Excessive Internet use can precipitate marked psychosocial dysfunction (Kormas et al. 2011). This gender disparity aligns with and expands upon existing literature. Previous studies have suggested that males and females may engage with the Internet differently, which can lead to varied behavioral outcomes (Lyu and Chai 2024). Our findings add a new dimension to this discourse by specifically linking these differential engagement patterns to externalizing problem behaviors, such as aggression and rule-breaking. Furthermore, the heightened susceptibility of male adolescents to the negative effects of Internet use observed in our study is consistent with the broader psychological and developmental research. For instance, studies by Li et al. (2024) have noted that male adolescents often

exhibit higher rates of externalizing behaviors due to a range of psychosocial factors. Our research suggests that Internet use may exacerbate these pre-existing tendencies. Importantly, our study highlights the need for a gender-sensitive approach in understanding the impact of digital technologies on adolescent development. This perspective is reinforced by research from Hasan et al. (2024), who emphasized the importance of considering gender differences in developmental psychology.

The urban-rural heterogeneity between Internet use and externalizing problem behaviors in early adolescents. This study also validates the sixth hypothesis (H6), which posits that Internet use exerts a substantial influence on the externalizing problem behaviors of early adolescents in both urban and rural settings, with marked differences between the two groups. Moreover, the detrimental effects of Internet use on externalizing problem behaviors are more pronounced in rural early adolescents compared to their urban counterparts. One possible explanation is that the migration of parents from rural areas to cities for work can lead to a lack of parental care and a weaker attachment between the parents and their children (Lan and Wang 2020; Wang et al. 2019), which may also lead to excessive Internet use (Cai et al. 2021). Internet addiction increases the incidence of adolescent problem behaviors (Sung et al. 2013). However, this result is against with previous studies that rural adolescents (eg. USA, Tanzania) are less likely to use the Internet than urban adolescents (Hale et al. 2010; Furuholt and Kristiansen 2007). This disparity echoes the growing body of research indicating that the context of Internet use, including geographic and socio-economic factors, plays a critical role in shaping its outcomes (Tranos and Stich 2020). The greater negative impact observed in rural adolescents aligns with studies by Roper et al. (2024), which suggest that limited access to resources and opportunities in rural areas might exacerbate the adverse effects of Internet use. Moreover, our study contributes to the discourse on the digital divide and its implications for adolescent development. As highlighted by Martínez-Domínguez and Fierros-González (2022), differences in access, usage patterns, and digital literacy between urban and rural adolescents can lead to divergent behavioral outcomes. The heightened vulnerability of rural adolescents in our study underscores the need for targeted interventions and policies that address these disparities. Interestingly, our research also aligns with the findings of Pineda and Vanegas (2024), who noted the unique challenges faced by rural adolescents in terms of Internet use and its implications for their social and emotional development. This suggests that the externalizing problem behaviors observed may be partly due to the distinct social and environmental contexts in rural areas.

Theoretical contribution and practical implications. The results from this study have implications and contributions from both theoretical and practical perspectives. In terms of theoretical contributions, first, this study provides insight into the mechanism behind the relationship between Internet use and early adolescent externalizing problem behaviors, which broadens and complements the previous research in this area (Guan 2013; King et al. 2018; Liu and Gao 2013; Piko et al. 2017; Yu 2020). This study also extends our understanding of the relationship between self-education expectation, peer relationships and externalizing problem behaviors from societal perspectives.

Our findings also have practical implications. Government should strengthen the education and training of early adolescents' online skills in rural areas as far as possible according to the actual situation of all regions to make the Internet truly a powerful and useful tool for rural early adolescents' study and life,

rather than just a simple entertainment tool. Social organizations should leverage community resources to address the practical challenges faced by special families. For instance, in cases where parents in rural areas work away from home and struggle to supervise their children's Internet use, social organizations can step in to provide necessary support, helping to mitigate these children's excessive reliance on the Internet. Schools have a crucial role in guiding early adolescents in appropriate Internet usage by tailoring their approaches to the distinct characteristics of male and female students. Specifically, schools should focus on enhancing attention management, self-regulation, and Internet literacy among male early adolescents. Parents, on their part, must model responsible Internet use. They should regulate their children's daily Internet time and monitor their online activities to prevent overuse. Additionally, parents should encourage their children to engage in outdoor activities with peers, thereby redirecting their focus from the virtual to the real world.

Limitations

The present research acknowledges several limitations. First, the data was sourced exclusively from three provinces—Liaoning, Henan, and Sichuan—which may limit the generalizability of the findings to the broader population. To enhance external validity and applicability, future research should aim for a nationally representative sample, addressing concerns of regional specificity and accounting for potential provincial variations in both Internet use and early adolescent externalizing problem behaviors.

Second, the reliance on self-reported data introduces potential biases, such as social desirability bias and recall bias, which may affect the accuracy of the findings. Social desirability bias may lead participants to provide responses that they perceive as more acceptable or favorable, while recall bias can result in inaccuracies in reporting past behaviors or experiences. To mitigate these biases, future research should consider incorporating multi-informant data sources, including input from parents, peers, and educators, as well as objective measures, to provide a more comprehensive and accurate understanding of the relationship between Internet usage and externalizing problem behaviors in early adolescents.

Third, the cross-sectional design of this study limits the ability to infer causality. This approach only provides a snapshot of the relationship between Internet use and early adolescent externalizing problem behaviors at a single point in time. Consequently, the temporal dynamics and potential causal directions between these variables remain unexplored. Future research should consider a longitudinal design. Tracking participants over extended periods would offer stronger evidence for causal relationships and allow for the examination of how these dynamics evolve over time.

Fourth, while this study offers valuable insights into the interplay among externalizing problem behaviors, self-education expectations, peer relationships, and Internet use, it is constrained by its focus on a specific mediation model. This narrow focus excludes potential alternative pathways, making the causal assertions of our proposed model preliminary. Future research should explore various mediation models using experimental or longitudinal designs to provide a more comprehensive understanding of these critical variables.

Finally, this study may not capture all potential determinants of early adolescent externalizing problem behaviors. Future research should consider a broader set of influential factors, addressing unanswered questions and contributing to a more holistic understanding of these behaviors.

Conclusions

This study examined early adolescent externalizing problem behaviors and explored several antecedent factors that influence

their externalizing problem behaviors. Specifically, this study found that Internet use might have a negative impact on early adolescent externalizing problem behaviors. Importantly, our study extends previous research by delineating the individual and combined mediating roles of self-education expectation and peer relationships in this relationship. Our findings suggest that both self-education expectation and peer relationships independently mediate the effect of Internet use on externalizing behaviors. Collectively, they establish a chain mediation pathway, thereby further elucidating the complexity inherent in these relationships. Additionally, this study revealed significant gender-related and urban-rural disparities in the effects of Internet use on early adolescent externalizing problem behaviors. The detrimental influence of Internet use on these behaviors was more pronounced among rural early adolescents compared to their urban counterparts. Similarly, male early adolescents experienced a greater negative impact from Internet use on externalizing problem behaviors than female early adolescents. This research provides both theoretical and practical contributions. Theoretically, it clarifies the relationship between internet usage and externalizing problem behaviors in early adolescents by exploring the underlying mechanisms. Practically, it investigates the factors contributing to these behaviors from both social and individual perspectives, offering a comprehensive understanding of early adolescent development. Consequently, the findings of this study provide valuable recommendations for policymakers, social organizations, educational institutions, and parents.

Data availability

Participants were informed during the data collection process that their information would remain confidential and that no one outside the research team would have access to the data, so the datasets generated and analyzed in this study cannot be shared publicly as this was explicitly stated in the consent forms.

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Author contributions

Xingchen Zhu: conceptualization, methodology, software, formal analysis, writing—original draft, writing—review & editing; Wencan Li: writing—original draft; Haohan Zhao: writing—original draft; Jinsheng Hu: writing—review & editing.

Ethical approval

The study was approved by the Research Ethics Committee of the School of Education at Liaoning Normal University (Ethics approval number: LSDJYXY2023002). This research complies with all relevant ethical guidelines, including the institutional protocols for research involving human participants and the Declaration of Helsinki. The ethics approval covered all aspects of the study, including participant recruitment, data collection, and analysis. All procedures were conducted in line with these regulations to ensure the protection of participants' rights, confidentiality, and informed consent throughout the research.

Informed consent

This study obtained written informed consent from both participants and their legal guardians, facilitated by trained research assistants prior to data collection in March 2023. Given the involvement of minors, special care was taken to ensure that consent was appropriately secured. Legal guardians were provided with clear information about the study's objectives, procedures, and participants' rights, highlighting the voluntary nature of participation and the right to withdraw at any time without penalty. Additionally, minors received age-appropriate explanations to help them understand the study's purpose and their role. Both legal guardians and minors signed the consent forms to confirm their understanding and agreement. Participants were assured that their anonymity and confidentiality would be strictly protected, with no personally identifiable information collected. The consent covered participation in the study, the use of collected data for research purposes, and permission to publish the findings. As a token of appreciation, participants received a small gift (e.g., a pen or card), regardless of whether they completed the study. This gift was provided solely as a gesture of gratitude, not as an incentive, ensuring the voluntary nature of participation was preserved.

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to Haohan Zhao or Jinsheng Hu.

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