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Article

Tethered Disparities: Adolescent Smartphone Use in Rural and Urban China

Huan Chen [1] and Zixue Tai [2,*]

[1] School of Journalism and Communication, Minjiang University, China
[2] School of Journalism and Media, University of Kentucky, USA

* Corresponding author (ztai2@uky.edu)

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Abstract
The pervasive penetration of the smartphone has disproportionately affected adolescents and youth more than any other sociodemographic group. Inspired by the conceptual framework of the digital divide in internet use, this research aims to interrogate the multi-dimensional aspects of disparities in smartphone use among teens in China. Measurement was developed to assess the first-, second-, and third-level divide as manifested in smartphone access and engagement in a variety of activities, different skill sets, and myriad outcomes and consequences. Results from a cross-sectional survey of 1,511 at-school teens show various patterns of divide along the lines of age, gender, and rural/mid-sized-city/metropolitan location.

Keywords
China; digital divide; media disparities; smartphone use; territorial gap

Issue
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1. Introduction

Like elsewhere, China has witnessed exponential penetration of the smartphone into many aspects of professional, social, and private life in the past decades. In parallel with this comes a milieu of environmental and situational factors that exacerbate the digital disparities and multifaceted manifestations of digital inclusion/exclusion along rural–suburban–urban lines, which may lead to varied outcomes in different facets of adolescent social and personal well-being. Inspired by the conceptual lens of the three levels of the digital divide in internet use, this research aims to interrogate the multiple dimensions of the digital divide in smartphone use by middle school and high school-age teens in China.

Our perspectives and analysis are informed by a cross-sectional survey of a stratified national sample of 1,511 at-school teens. The first-level of the digital divide concerns access to smartphone technologies and engagement with various activities. The second-level divide is measured by four core smartphone skills categories, adapted from well-established traditions of internet skills assessment. The third-level divide is based on adolescents' self-assessment of an assortment of evaluations in the areas of positive, negative, and utilitarian outcomes in relation to smartphone use. Key variables moderating the digital divide of smartphone use are rural–suburban–urban location and gender. The findings are discussed in the broad context of the digital divide research and China's youth-led techno culture.

2. Digital Divide: First-, Second-, and Third-Level Dimensions

2.1. From Access to Skills

As digitization takes center stage in global society, the digital divide has been a prevailing topic of academic interest in the past decades. Originally defined as the inequality (gap) between those who have access and do not have access to the internet in the 1990s (van Dijk, 2020), research in the early years had primarily conceptualized the digital divide along the binary distinction between access/non-access to and use/non-use of the internet among various segments of the population (Rogers, 2001). As an increasing proportion of the population gains access to the internet and related digital technologies, the barrier to connection no longer poses a problem to the vast majority of the general public. Research focuses have subsequently shifted to other dimensions of access and use that shape new formations of the digital divide (Min, 2010; van Deursen & van Dijk, 2014).

In response to these new developments, scholars contend that the digital divide can no longer be construed solely on the "have vs. have-not" distinction, and instead must be interpreted on differentiation along other important dimensions such as skills and knowledge (Scheerder et al., 2017), quality of connection and accessibility of relevant content (DiMaggio et al., 2004), attitudes and amount/varieties/patterns of usage (Blank & Groselj, 2014; van Deursen & van Dijk, 2014), as well as Web 2.0 literacy (Friemel & Signer, 2010). This line of research and conceptual contemplation is commonly referred to as the *second-level digital divide* (Hargittai, 2002), aiming to differentiate this marked shift from a primary focus on the access divide (i.e., the first-level digital divide) to the skills divide. Cross-national survey data by Büchi et al. (2016) confirm the existence of the second-level digital divide in high-penetration countries, supporting the argument that widespread internet access does not translate into usage equality. Similar gap patterns in technical skills and motivations have been observed in (low penetration) Sub-Saharan Africa (Ogbo et al., 2021), Cuba (van Deursen & Andrade, 2018), and adolescents in Central and Eastern Europe (Barbovschi & Balea, 2013).

2.2. Benefits and Outcomes

Research in recent years has expanded into investigating the miscellaneous consequences and outcomes of digital media use, collectively labeled the *third-level digital divide* to highlight the "gaps in individuals' capacity to translate their internet access and use into favorable offline outcomes" (van Deursen & Helsper, 2015, p. 30). Livingstone et al.'s (2023) sweeping overview of 34 empirical studies on the outcomes of children and young people's digital skills in multiple national settings reveals that different skill dimensions are linked to different outcomes, but not always beneficially. While greater technical skills are linked to more online opportunities and information benefits, they are also found to be associated with more online risks. Informational skills, on the other hand, are generally found to be linked to beneficiary outcomes (Livingstone et al., 2023; Scheerder et al., 2017). The fact that access does not automatically translate into skills, which in turn do not equate to positive outcomes lends support to the argument in favor of perceiving the digital divide "as a multidimensional phenomenon that includes a set of complex divides…caused by a variety of factors" (Bruno et al., 2011, p. 27). With specific regard to online health care, access to online services, skills to use them and the extent of use play crucial roles in perceived health, economic, and collaboration benefits (Heponiemi et al., 2020). Ragnedda et al. (2022) argue that stratified access to ICTs among different types of users may reinforce "the inequality loop" that leads to diverging outcomes in the internet experience. Inequalities in benefits and harms driven by algorithm sorting, data mining, and artificial intelligence are important issues to investigate as individual interactions with emerging technologies intensify (Lutz, 2019).

2.3. Measurement and Assessment of Digital Skills

One area that has received significant scholarly attention is the measurement of internet skills (i.e., the second-level divide). It has been duly noted that there is a wide range of methodological approaches to assessing internet skills, from surveys to interviews and experiments (Litt, 2013). In general, following van Deursen and van Dijk, (2010), measurement of internet skills has been operationalized in the framework of these dimensions: operational skills (a set of basic skills in using the computer or the internet); formal skills (skills related to the structure of the internet medium); information skills (searching, retrieving, and making judgment about information online); and strategic skills (setting a goal orientation and taking action accordingly). In a similar vein, van Dijk's (2020) resources and appropriation theory of the digital divide makes the distinction between two broad types of medium-related (operational and formal skills) and content-related (information, communication, strategic, and content-creation) skills. With regard to outcomes of internet use (i.e., the third-level digital divide), the most commonly adopted perspective is to operationalize outcomes in multiple life realms pertinent to a variety of economic, social, political, and educational consequences (van Deursen & Helsper, 2015; van Dijk, 2020).

2.4. Smartphone-Based Mobile Communications

The particular affordances of the smartphone, its highly personal nature, coupled with its ubiquity, crosscut the human/machine boundaries and cultivate incorporeal embodied experiences of *homo prostheticus*, that is, living one's life with and through the phone (Marchant & O'Donohoe, 2019). Smartphone-based communication is of particular importance to adolescents and young adults, configuring into a distinct "youth mobile culture" (Vanden Abeele, 2016). Traditionally, research investigating the digital divide has been dominated by internet use, and it is within recent years that growing attention has been extended to the various dimensions of the smartphone usage gap and divide. For example, Tsetsi and Rains (2017) analyzed the divide in smartphone dependence along major socioeconomic and race factors. Vimalkumar et al. (2021) offer a cross-national comparison of the multi-level nature of the divide in smartphone adoption and usage. Despite the emerging body of research in this area, as Marler (2018) notes, many pressing issues such as how particular conditions of disadvantage and infrastructural affordances shape outcomes for diverse groups and marginalized communities await academic attention. One specific example is health app use, the gradations of which may contribute to new digital inequalities (Bol et al., 2018).

One fundamental difference between the internet and smartphone use is that the former has been generally portrayed in a positive light (as something to be desired and needed, e.g., DiMaggio et al., 2004; van Dijk, 2020). The smartphone has been quite a different story, however. Although the smartphone is associated with miscellaneous benefits and opportunities, it is also frequently associated with myriad risk factors and harm, such as addiction, cyberbullying, distress and anxiety, and physical and mental health, in particular relevance to children and youth (Fischer-Grote et al., 2021; Mascheroni & Ólafsson, 2014).

2.5. Research Questions

The purpose of our research is to dissect the multiple dimensions of the digital divide as manifested in smartphone use among school-age teens in China along lines of urban–rural residence. Specifically, we were interested in the full spectrum of the digital divide ranging from access to skills and consequences with the middle school and high school population. In conformity with the above literature review, we developed the following set of broad research questions to pursue:

RQ1: What are the gaps among teens regarding access to smartphone devices and their common features?

RQ2a: What gaps, if any, are there concerning patterns of smartphone usage and activities among metropolitan, mid-sized cities, and small-town/rural teens?

RQ2b: What is the variation in their diverse smartphone skills among metropolitan, mid-sized cities, and small-town/rural teens?

RQ3: How does the digital divide in smartphone use manifest in a tangible impact on the teens' social and academic lives?

RQ4: What are the intervening roles of gender and age in the smartphone digital divide?

3. Methodology

3.1. Participants

Our main focus was to examine the multi-level digital divide in smartphone use based on residential type variation. Geographic affiliation in China dictates economic, social, and informational resources in the local lifestyle and therefore creates natural conditions of inequality for residents in these areas. People living in the biggest metropolises typically have access to up-to-date technological infrastructure, while residents in remote rural areas significantly lag behind. We divided location types into three broad categories: metropolises, mid-sized cities, and small towns/rural areas. Metropolises include prefecture- and provincial-level cities, with a typical population of a few million and served by the best telecommunications infrastructure. Mid-sized cities are mostly county-level cities with a population of a few hundred thousand, while small towns/rural locations refer to township-level or below-residential areas with low population density.

We utilized a stratified sampling strategy in selecting participants in the study. Locations were first selected from different geographic regions spanning across 18 provincial areas, followed by the identification of schools in the chosen locations. Four types of schools were targeted in the sampling process: middle schools (grades 6–8), high schools (grades 9–12), junior secondary vocational schools (grades 6–8), and senior secondary vocational schools (9–12). Sixty schools were initially identified, and teachers were contacted in these schools for permission to recruit students. Thirty-nine schools eventually agreed to let their students participate in the online survey. One to two grades were selected from each school. Consent was obtained through both the parents and the teens with a recruiting letter explaining the overall purpose of the survey (smartphone use) and its strictly voluntary nature of participation.

The survey was posted on Wenjuanxing (www.wjx.cn), China's most popular online survey platform. Students who agreed to participate were asked to provide their answers either on a computer or smartphone, and the survey was conducted from 20 March to 15 April 2023. Out of 2,425 students contacted for the survey, a total of 1,511 valid responses were collected after four incomplete questionnaires were tossed out, representing a response rate of 62.3%. Detailed information about the participants is reported in Table 1. Participants range from 12 to 19 years old, with an M = 15.62 in age. Gender is rather evenly distributed, as is geographic location in its three categories.

3.2. Survey Tools

Our first-level divide measurements include the following: accessibility to smartphones, type of smartphone

Table 1. Sample characteristics.

Variables	*N* = 1,511 (100%)
Gender	
Male	763 (50.5%)
Female	748 (49.5%)
Age (*M* = 15.62; *SD* = 2.15)	
12	77 (5.1%)
13	232 (15.4%)
14	295 (19.5%)
15	136 (9.0%)
16	160 (10.6%)
17	235 (15.6%)
18	207 (13.7%)
19	169 (11.2%)
Grade	
Middle school year 1	315 (20.8%)
Middle school year 2	344 (22.8%)
Middle school year 3	71 (4.7%)
High school year 1	78 (5.2%)
High school year 2	278 (18.4%)
High school year 3	238 (15.8%)
Other	187 (12.4%)
Location type	
Metropolis	460 (30.4%; 247 males vs. 213 females)
Mid-sized city	497 (32.9%; 257 males vs. 240 females)
Small town/rural area	554 (36.7%; 259 males vs. 295 females)
Provincial regions	18
Average smartphone time (weekdays)	
Less than 1 hour	747 (49.4%)
1 to less than 2 hours	278 (18.4%)
2 to less than 3 hours	142 (9.4%)
3 to less than 4 hours	104 (6.9%)
4 hours or more	240 (15.9%)
Average smartphone time (weekend)	
Less than 1 hour	276 (18.3%)
1 to less than 2 hours	342 (22.6%)
2 to less than 3 hours	261 (17.3%)
3 to less than 4 hours	181 (12.0%)
4 hours or more	451 (29.8%)
Price range	
Below ¥1,000	265 (17.5%)
¥1,000–¥1,999	673 (44.5%)
¥2,000–¥2,999	309 (20.5%)
¥3,000 and above	264 (17.5%)

used, and how often one engages in a dozen of smartphone-based activities. Smartphone skills (the second-level divide) measurements were adopted from well-established frameworks in the digital divide research tradition (Litt, 2013; van Dijk, 2020), with customized adaptations to the peculiarities of smartphone use. We adopted the three categories of operational, informational, and strategic skills from van Deursen and van Dijk (2010) but revised the formal skills for internet use into a new category called *advanced skills* to measure one's ability to understand and take advantage of some advanced features on the smartphone. We initially developed a list of 25 items assessing individuals' proficiency/familiarity in accomplishing specific tasks on the smartphone and sent them out to a dozen middle school and high school teachers as well as parents for comments and feedback for both wording appropriacy and skills coverage. Revisions were made and then these measurements were pilot-tested with 15 middle schoolers and 15 high schoolers. Based on comments and suggestions in the two rounds of evaluations, we adopted a list of 17 indicators in our online questionnaire.

Operational skills were measured by six items: set up wake-up services and timer functions; use the GIS as well as the GPS service; create a WeChat or a QQ group; use video, audio, or email service; share images or videos with others; find and install apps that one needs. Informational skills were measured by these five indicators: shop and complete smartphone-based purchases; find information that helps one's routine life; buy tickets (e.g., movies and public transportation); find out what is going on in one's community; find answers to everyday questions.

Strategic skills were assessed by one's ability to perform these tasks (towards education-related goals): find answers to questions related to school education; help with one's homework and academic tasks; use the smartphone to improve one's grade; use the smartphone to enhance one's knowledge level. Finally, the advanced skills instrument contained two items: understand smartphone technical specifications and make customized settings for particular needs; and personalize security settings to enhance privacy and safety. Each indicator asked participants their level of familiarity with performing the referenced tasks on a 5-point scale, with 1 = *most unfamiliar* and 5 = *most familiar*. A composite score was calculated for each of the four skill sets by summing up the scores of the respective items used in each category. For ease of comparison, we standardized all four measurements into a 1–5 scale (Table 3).

Regarding the third-level divide in reference to the varied outcomes and consequences of smartphone use, we developed a series of 11 items covering how the smartphone has impacted one's communication, academic pursuit, community life, and entertainment. Participants were asked to respond on a 6-point scale (1 = *strongly disagree* and 6 = *strongly agree*) to what extent each item fits their individual smartphone use outcomes. We classify these statements into three broad categories (positive, negative, and neutral). Positive outcomes refer to favorable impacts and benefits smartphone use has exerted on the individuals, including these 5 items: "The smartphone enhances my understanding of and communication with my family"; "the smartphone brings me joy"; "I learn a lot of extracurricular knowledge on the smartphone"; "the smartphone brings me a lot of convenience in my life"; "smartphone use deepens my understanding of the community and neighborhood I live in."

Negative outcomes, on the contrary, pertain to undesirable and detrimental consequences on teens' academic or social life, as demonstrated in these four items: "The smartphone interferes with my school work and drags down my GPA"; "the smartphone distances me from my friends"; "I feel ill at ease if I am separated from my phone"; "smartphone use brings me distress and frustration." Neutral outcomes contain two statements related to the utility aspects of the smartphone as a tool for entertainment and information-seeking: "The smartphone is an important source of information for me"; "the smartphone is the main platform of after-school entertainment for me." Cronbach's alpha (α), which measures scale reliability, is 0.898 for the positive outcomes scale, 0.902 for the negative outcomes scale, and 0.796 for the utility measure. Thus, a high level of internal consistency was achieved in the multi-dimensional indicators. Notably, the alpha value for the utility scale ranks much lower than that for negative and positive outcomes, most likely attributable to the small number (n = 2) of measurement items for utility. As Tavakol and Dennick (2011) explain, short test length (i.e., fewer test items on the scale) reduces the value of alpha.

3.3. Data Analysis

Data analysis was performed using IBM SPSS Statistics (Version 29). Aligned with our interest in examining differences across the demographic characteristics of gender and age within the various location types, multivariate analysis of variance (MANOVA) was the major statistical procedure using the various dimensions of smartphone as the dependent variable, with gender and location type as the independent variables and age as a covariate. When the MANOVA results indicated significant groupwise differences, follow-up post-hoc between-group tests were conducted to pinpoint patterns of pairwise differences per recommended MANOVA practices (Denis, 2021). Additionally, we started out with the MANOVA full model including interaction effects. In models that did not show significant interaction effects, we resorted to a model with only parameters of the main effects reported.

4. Findings

4.1. Access (First-Level Divide)

As an indication of the pervasive penetration of the smartphone in China, there was no report of individuals not having access to the device in our sampling process. However, there exists a gap along rural–urban lines in other measures of mobile access. Asked whether they had wi-fi access at home, 14.8% of rural teens responded with "yes," compared with 9.5% of suburban and 6.1% of urban teens (χ^2 = 21.19, p < 0.001). There is also a disparity in terms of the type of smartphone the adolescents gain access to. This is reflected in the price tag the survey asked for the phone they currently had: small-town/rural teens had the highest percentage (20.4%) in the lowest category (less than ¥1,000) while the lowest percentage (11.2%) in the highest cost category; metropolitan teens were exactly the opposite and mid-sized city teens were in between (χ^2 = 69.80, p < 0.001). In responding to how frequently they obtained a new phone set (every year, every two–three years, or over three years), rural teens reported the largest percentage (66.4% vs. 48.1% urban) on taking over three years to get a replacement, while their metropolitan peers had the highest percentage (17.4% vs. 4.6% rural) on receiving an upgrade every year; teens from mid-sized cities fell in the middle in these categories ($\chi^2 = 73.72$, $p < 0.001$).

Table 2 tabulates nine smartphone activities that teens engage in, ranked in the order of the overall means from most often to least often. Three activities in the survey that scored the lowest frequency (e-purchase, e-health, and making new friends) were excluded. There is a significant main effect of location on all activities except using Douyin (the domestic version of TikTok) and Kuaishou (a short-video sharing app); teens in big cities consistently display a higher propensity to engage than their counterparts in mid-sized cities and small town/rural areas on the eight other activities. Post-hoc tests revealed that the suburban-rural gap only reaches statistical significance with regard to virtual classes and online education for both male and female teens. Male teens in metropolitan regions tend to perform more activities in the areas of voice calls and SMS, utility apps, news-related information-seeking, and camera use than their rural peers. While the general tendency is for female adolescents to engage more in smartphone activities, the lone exception is mobile gaming, where male cohorts show a higher propensity to play games among all metropolitan, mid-sized cities, and small-town/rural locations. As a matter of fact, the gender main effect ($F = 39.78$) is second only to that ($F = 43.03$) in phone camera use, but the latter points to the opposite direction (i.e., females take more photos than males). The location effect is the largest in news-related information seeking ($F = 39.20$) and virtual class ($F = 36.55$).

A significant main effect of age was detected on all activities, suggesting a clear pattern of differentiation along this dimension. There is a persistent divergence

Table 2. MANOVA results and pairwise comparison of smartphone activities.

Activity type Overall *M* (*SD*)		Location group mean (*SD*) Small town/ rural area	 Mid-sized city	 Metropolis	MANOVA results (main effects)
Social networking apps (WeChat and QQ) and email ($M = 3.40$; $SD = 0.81$)	Male Female	3.21 (0.95) 3.41 (0.86)	3.28 (0.81) 3.43 (0.71)	3.49 (0.74) 3.59 (0.66)	Location: $F = 16.30$; $p < 0.001$ Gender: $F = 19.75$; $p < 0.001$ Age: $F = 170.86$; $p < 0.001$
Voice calls and SMS ($M = 3.27$; $SD = 0.84$)	Male Female	3.11 (0.89) 3.20 (0.89)	3.26 (0.82) 3.20 (0.84)	3.41 (0.81) 3.53 (0.70)	Location: $F = 20.64$; $p < 0.001$ Gender: $F = 18.83$; $p < 0.145$ Age: $F = 79.49$; $p < 0.001$
Virtual class and education-related tasks ($M = 3.23$; $SD = 0.79$)	Male Female	3.01 (0.84) 3.13 (0.78)	3.19 (0.82) 3.26 (0.69)	3.38 (0.80) 3.50 (0.66)	Location: $F = 36.55$; $p < 0.001$ Gender: $F = 8.90$; $p = 0.003$ Age: $F = 89.23$; $p < 0.001$
Calculator, calendar, dictionary, and clock ($M = 3.23$; $SD = 0.85$)	Male Female	2.98 (0.92) 3.22 (0.84)	3.15 (0.84) 3.27 (0.78)	3.33 (0.84) 3.47 (0.77)	Location: $F = 21.96$; $p < 0.001$ Gender: $F = 2.13$; $p = 0.001$ Age: $F = 80.92$; $p < 0.001$
Video, music, and e-reading ($M = 3.19$; $SD = 0.86$)	Male Female	3.01 (0.97) 3.18 (0.83)	3.02 (0.91) 3.26 (0.74)	3.27 (0.87) 3.46 (0.73)	Location: $F = 19.26$; $p < 0.001$ Gender: $F = 18.87$; $p < 0.001$ Age: $F = 192.70$; $p < 0.001$
Douyin, Kuaishou, and livestreaming ($M = 3.14$; $SD = 0.92$)	Male Female	3.13 (0.98) 3.16 (0.90)	3.06 (0.94) 3.15 (0.80)	3.18 (0.97) 3.19 (0.90)	Location: $F = 1.31$; $p = 0.269$ Gender: $F = 2.00$; $p = 0.157$ Age: $F = 133.09$; $p < 0.001$
News-related information ($M = 2.89$; $SD = 0.93$)	Male Female	2.63 (1.04) 2.80 (0.89)	2.85 (0.93) 2.80 (0.86)	3.16 (0.91) 3.16 (0.85)	Location: $F = 39.20$; $p < 0.001$ Gender: $F = 2.19$; $p = 0.139$ Age: $F = 155.84$; $p < 0.001$
Mobile games ($M = 2.87$; $SD = 0.97$)	Male Female	2.98 (0.94) 2.61 (0.97)	2.99 (0.95) 2.66 (0.93)	3.14 (0.91) 2.89 (1.04)	Location: $F = 9.57$; $p < 0.001$ Gender: $F = 39.78$; $p < 0.001$ Age: $F = 88.66$; $p < 0.001$
Photo-taking (including selfies) ($M = 2.83$; $SD = 1.01$)	Male Female	2.51 (1.05) 2.91 (0.95)	2.61 (1.00) 2.88 (0.96)	2.97 (1.03) 3.17 (0.96)	Location: $F = 24.53$; $p < 0.001$ Gender: $F = 43.03$; $p < 0.001$ Age: $F = 180.80$; $p < 0.001$

Note: Scale—1 = *seldom or never*, 2 = *occasionally*, 3 = *often*, and 4 = *almost always*.

among teens from metropolises, mid-sized cities, and small town/rural areas in the 12–15-year-old (middle schooler) range, and that gap tapers off among the 16–19-year-old cohort (high schoolers). Due to space constraints, we only presented figures demonstrating the age effects for the top-four smartphone activities in Figure 1. Of note is the persistent rural-urban gap with regard to virtual classes and online education across all age groups. An identical pattern of persistent location disparity was only noted for news-related information seeking among all the activities (not listed in Figure 1).

4.2. Smartphone Skills (Second-Level Divide)

As might be expected, respondents scored the highest level of proficiency in operational skills (M = 4.04) and the lowest level in advanced skills (M = 3.64). Along the lines of the rural–urban divide, informational skills have the biggest disparity as reflected by the F value (105.72), suggesting that the inequality among rural, mid-sized city, and metropolitan teens is the most intense therein. As far as gender is concerned, the size of the main effect is the biggest in strategic skills, indicating that female teens are much more strategic than their male peers in using smartphones to accomplish school and other goal-oriented tasks. As Table 3 shows, there is a continuous gap between all four types of smartphone skills separating rural, mid-sized city, and metropolitan teens. Female teens are significantly ahead of male teens in operational, information, and strategic skills, but they trail behind male teens in their advanced skills, albeit not at a level of statistical significance.

Because age displays an invariably large main effect on all four skill categories, we graphically represented the variations within the different age cohorts in relation to the four skill sets in Figure 2. It can be seen

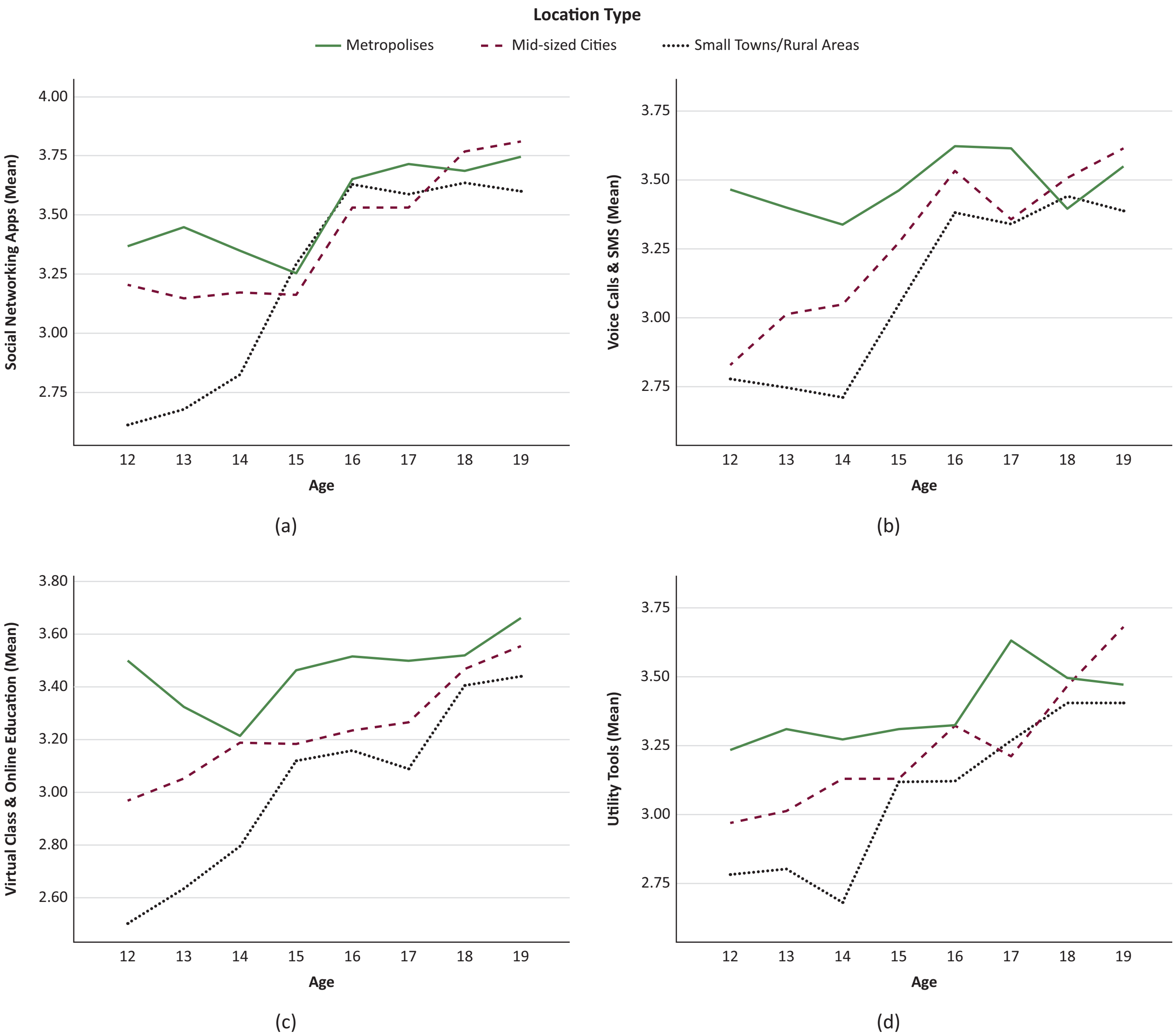

Figure 1. Variation of smartphone activities by age: (a) social networking apps; (b) voice calls and SMS; (c) virtual class and online learning; (d) utility tools. Note: Scale ranged from 1 = *never* to 4 = *very frequently*.

Table 3. Comparison of smartphone skills.

Smartphone skills Overall M (SD)		Location group mean (SD): Smal town/ rural area	Mid-sized city	Metropolis	MANOVA results: Location effect F ratio (df = 2)	Gender effect F ratio (df = 1)	Age effect
Operational skills (M = 4.04; SD = 0.94)	Male Female	3.72 (1.10) 3.83 (0.96)	3.94 (0.90) 3.99 (0.80)	4.40 (0.85) 4.46 (0.72)	F = 83.63; $p < 0.001$	F = 5.01; p = 0.025	F = 192.66; $p < 0.001$
Informational skills (M = 3.93; SD = 1.02)	Male Female	3.58 (1.22) 3.72 (1.06)	3.82 (0.82) 3.84 (0.86)	4.37 (0.86) 4.41 (0.82)	F = 105.72; $p < 0.001$	F = 4.66; p = 0.031	F = 325.35; $p < 0.001$
Strategic skills (M = 3.97; SD = 0.98)	Male Female	3.66 (1.11) 3.78 (1.00)	3.88 (0.96) 3.91 (0.88)	4.29 (0.89) 4.44 (0.75)	F = 76.70; $p < 0.001$	F = 7.42; p = 0.007	F = 194.06; $p < 0.001$
Advanced skills (M = 3.64; SD = 1.15)	Male Female	3.40 (1.28) 3.33 (1.09)	3.58 (1.08) 3.49 (1.03)	4.13 (1.07) 4.03 (1.04)	F = 71.05; $p < 0.001$	F = 1.04; p = 0.307	F = 215.31; $p < 0.001$

Note: Standardized scale—1 = *most unfamiliar*, 2 = *familiar*, 3 = *slightly familiar*, 4 = *unfamiliar*, and 5 = *most familiar*.

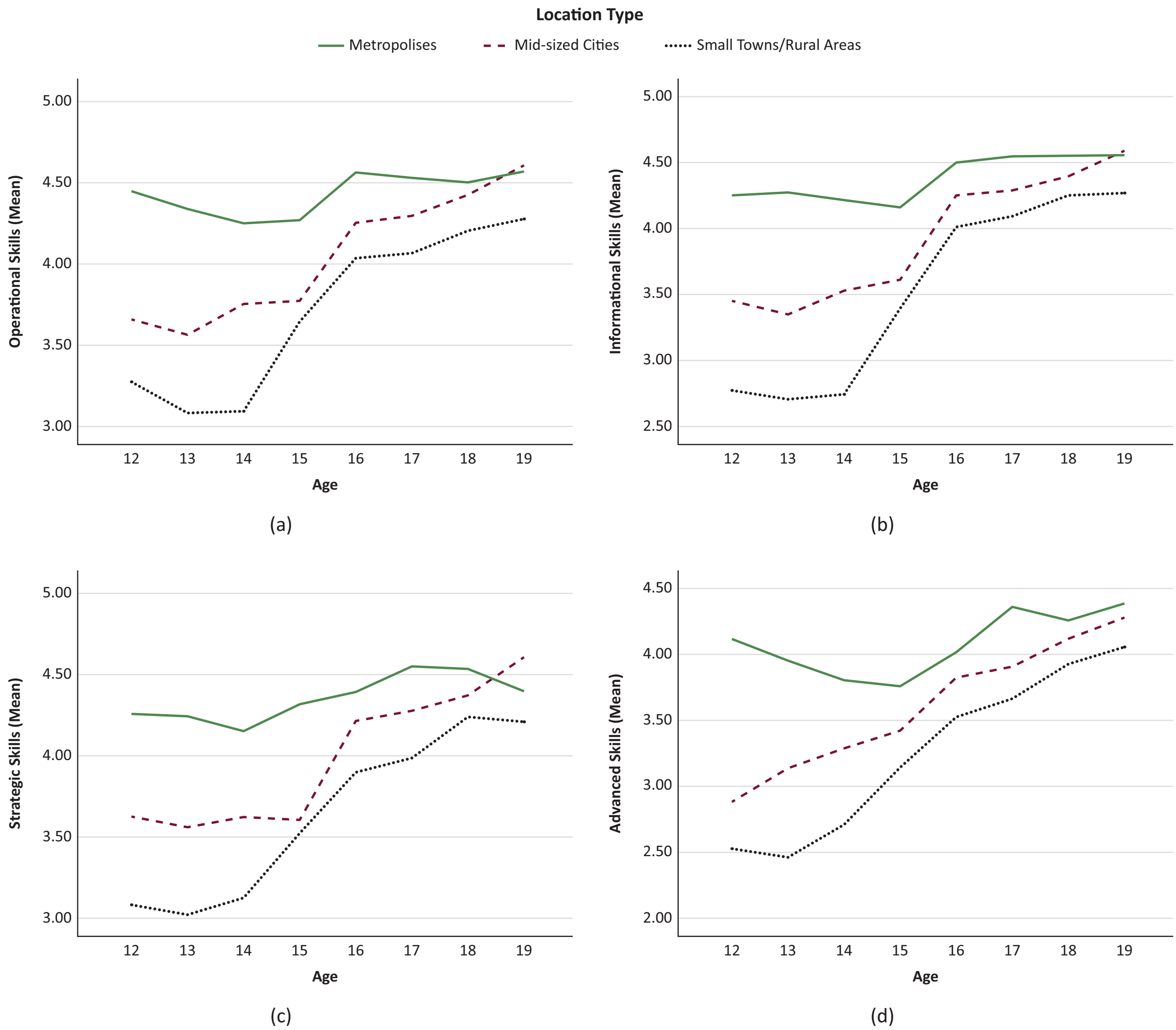

Figure 2. Age effects on smartphone skills: (a) operational skills; (b) informational skills; (c) strategic skills; (d) advanced skills.

that the small town/rural, mid-sized city, and metropolitan gap persists across all age groups. The disparity is the widest at age 12, and it gradually trends down and converges closer at age 19. This indicates that although small-town/rural and mid-sized city teens start off sizably behind their metropolitan counterparts, they can slowly catch up and narrow the gap as they move forward with their school. Across all four skill categories, metropolitan teens start at a much more proficient level, and their skills remain relatively stable as age goes up. This pattern is in distinct contrast to mid-sized city and small-town/rural adolescents, as proficiency level shows a clear pattern of improvement in parallel with the growth of age.

4.3. Outcomes and Consequences (Third-Level Divide)

Adolescents were overwhelmingly favorable about the positive outcomes of smartphone use (M = 4.35, see Table 4). On a scale from 1 (*strongly disagree*) to 6 (*strongly agree*), 80.8% answered in the positive territory (i.e., 4–6 on the scale). However, there is a sizable gap in perceived benefits of the smartphone between metropolitan teens on the high end and small-town/rural and mid-sized city teens on the lower end. It is a quite different story concerning the negative outcomes of smartphone use, as the average of responses (M = 3.31) falls right at the somewhat *disagree*/*agree* point of the scale, and 58.3% of the participants answered in the *disagree* range (1–3 on the scale) that the smartphone has produced a negative impact on their school and social life. The main effect of gender is the largest with the negative outcomes, showing males being affected more than females among all cohorts. Small-town/rural females perceived the least harm while metropolitan males felt the most. Location type has the biggest main effect on smartphone utility. The majority (60%) of the surveyed teens answered in the *disagree* category (i.e., 1–3 on the scale), with most of the responses coming from small-town/rural and metropolitan teens. Small-town/urban adolescents, on the other hand, perceived the most benefits in using the smartphone for task-oriented goals.

Because the main effects of age are quite massive in all the MANOVA results, we again plotted variations of the smartphone use outcomes along age groups. As revealed in Figure 3, metropolitan teens stay on top of all categories. Positive outcomes are exhibited early on across all groups with a threshold value of bigger than 3.5, whereas negative outcomes tend to emerge in the high school (16–19 years old) phase for metropolitan and mid-sized city teens and later high school for small-town/rural teens. Utility and positive outcomes show the most upward trend during high school years.

5. Discussion

A highly useful perspective for understanding disparities in smartphone use is the digital divide framework, which has attracted a robust body of scholarship in the wake of the rise of the internet since the 1990s. Nonetheless, digital divide research has been predominantly focused on internet use, and the smartphone has been sparingly examined in this context. To our knowledge, this current study represents the first effort to adopt the latest digital divide theoretical contemplations to systematically investigate multi-dimensional disparities in adolescent smartphone use along the geographic factor of rural-urban distribution.

As smartphones become ubiquitous in everyday life, how smartphone usage figures in the digital divide becomes a pivotal line of inquiry. It is therefore time that we scrutinized the diverse patterns of engagement with miscellaneous smartphone technologies and features as well as its subsequent consequences, in particular relevance to socially disadvantaged groups and demographics. The extant perspectives have been dominated by smartphone dependence as it relates to access to an

Table 4. Outcomes of smartphone use.

Outcome type Overall M (SD)		Location group mean (SD): Small town/ rural area	Mid-sized city	Metropolis	MANOVA results (main effects)
Positive outcomes (M = 4.35; SD = 1.42)	Male Female	4.16 (1.34) 4.27 (1.06)	4.20 (1.12) 4.18 (1.00)	4.73 (1.12) 4.66 (1.10)	Location: F = 33.40; p < 0.001 Gender: F = 0.544; p = 0.461 Age: F = 141.24; p < 0.001
Negative outcomes (M = 3.31; SD = 1.15)	Male Female	3.32 (1.43) 2.95 (1.21)	3.38 (1.36) 3.04 (1.15)	3.86 (1.61) 3.39 (1.56)	Location: F = 21.69; p < 0.001 Gender: F = 27.52; p < 0.001 Age: F = 124.15; p < 0.001
Utility (neutral) outcomes (M = 4.03; SD = 1.36)	Male Female	3.95 (1.50) 3.81 (1.28)	3.94 (1.33) 3.75 (1.21)	4.44 (1.30) 4.38 (1.35)	Location: F = 31.55; p < 0.001 Gender: F = 2.22; p = 0.136 Age: F = 225.78; p < 0.001

Note: Standardized scale from—1 = *strongly disagree*, 2 = *disagree*, 3 = *slightly agree*, 4 = *slightly disagree*, 5 = *disagree*, and 6 = *strongly agree*.

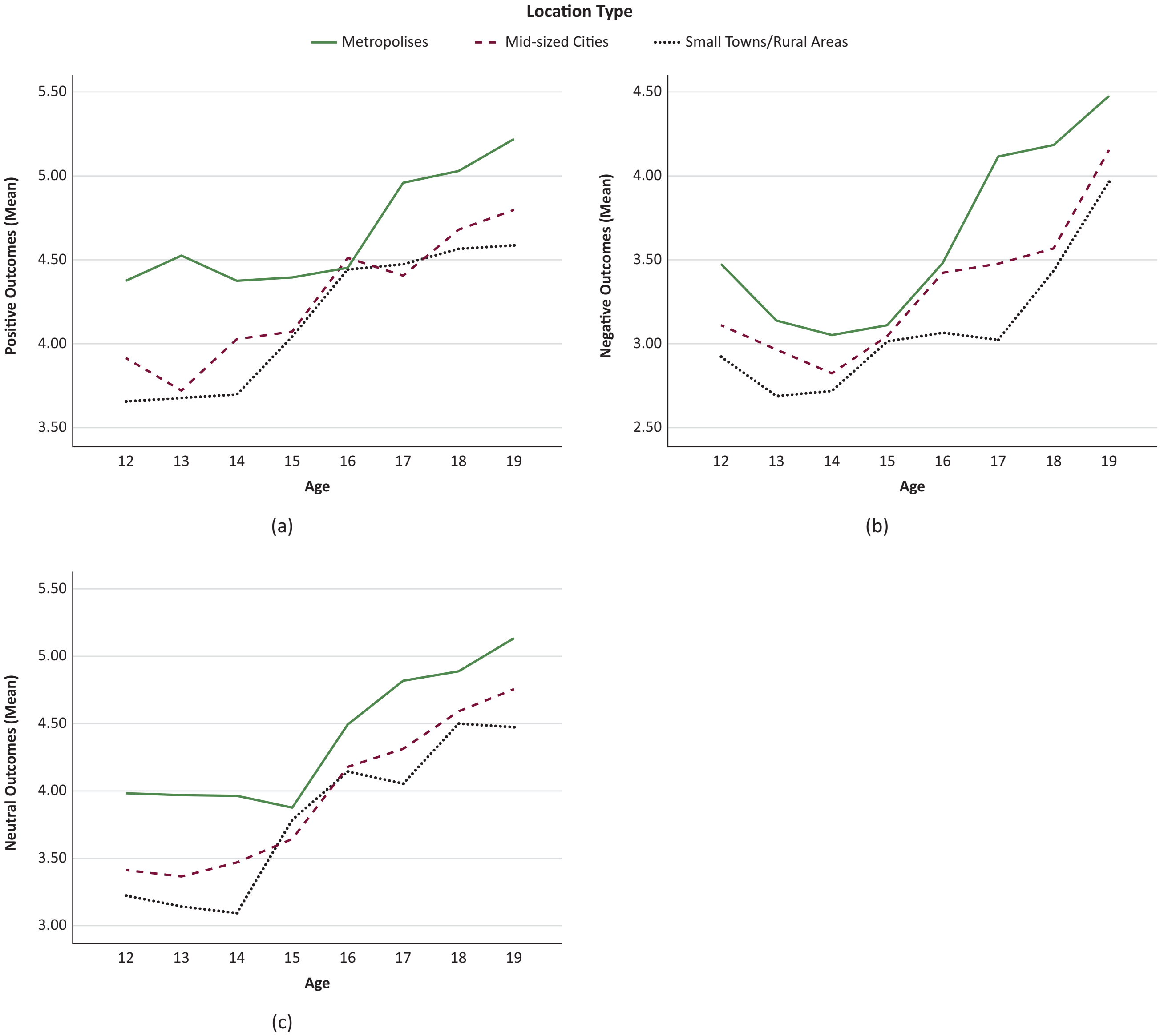

Figure 3. Age effects on outcomes: (a) positive outcomes; (b) negative outcomes; (c) neutral outcomes.

array of services and content types (i.e., the first-level digital divide; Park & Lee, 2015; Tsetsi & Rains, 2017). Our research demonstrates the critical importance of going beyond the first-level of access and extending to the second-level of skills and competence and the third-level of outcomes in gaining a fuller understanding of the digital divide in smartphone use.

Our research questions were inspired by the three levels of the digital divide encompassing access, skills, and outcomes. Built on measurement items tailored to the particularities of teens' smartphone engagement, findings in our cross-sectional survey of a national sample of 1,511 teens in China have several contributions to make to the broad field of smartphone digital divide research. First of all, the pervasive penetration of the smartphone means that accessibility of the device is not an issue for the vast majority of the teen population. This cannot be construed, however, as the diminishment of the digital divide in adolescent smartphone use. Besides inequality in the type and grade of devices, teens from small towns/rural areas, mid-sized cities, and metropolises also display distinct gap patterns in engaging with various activities on the smartphone. In particular, the location factor has the most impact on two activities—news-related information seeking, and virtual classes and online learning—which may suggest external, ecological circumstances such as lack of resources in small-town/rural and mid-sized city schools in utilizing the smartphone for educational purposes and comparative deficiency of news and other information directly relevant to the teens in these areas. Another interesting observation is the change in patterns of smartphone engagement from middle school to high school-age teens, which warrants further investigation.

At the skills (second-level divide) dimension, the gap endures (even though it shrinks as age levels up) through the 12–19 age groups along lines of metropolitan, mid-sized city, and small-town/rural distribution in all four (operational, informational, strategic, and advanced) skills categories. The cause of this continual gap, and more importantly, potential measures to mitigate it, are valuable areas to pursue in future research. The gap shows signs of tapering off or disappearing at the end (19-year-old group), and whether this is due to measurement error or whether it points to a new trend at the end of high school is an intriguing question worth additional scrutiny. Urban adolescents start with a much higher skill level than metropolitan teens, who in turn have a head start over their small-town/rural peers. This is most likely due to prior smartphone experiences and indicates that the divide exists among pre-middle school children.

Smartphone use is a double-edged sword in that positive outcomes and negative outcomes often go side by side. Teens generally rate quite favorably the rewards and benefits of the smartphone in their school and social life, even though metropolitan teens stay ahead of their mid-sized city and small-town/rural counterparts in the perceived positive outcomes. On the other hand, urban adolescents also lead their suburban and rural peers in feeling the negative consequences of smartphone use. Because the smartphone has been portrayed extensively in a negative light in the extant literature with regard to adolescents, a highly recommended line of research is to examine the interaction between positive and negative outcomes of smartphone use through the digital divide lens along dimensions of important sociodemographic and regional variables.

Methodologically, it is our hope that this research offers insight into measurement tools and assessment scales in the three levels of the digital divide concerning smartphone use. Current literature has been dominated by internet use scales, and scant attention has been paid to smartphone engagement. As the smartphone assumes elevated prominence in society, the importance of validated reliable measurements in empirically dissecting the digital divide and its various consequences cannot be overestimated.

Finally, the findings of this research should be evaluated against the backdrop of its limitations. Our classification of location into three broad types may hide some significant inter-regional differences in each of the categories. For example, county-level cities vary quite a bit in China, and collapsing multiple cities into a single category may hinder the discovery of other important intervening variables influencing key dynamics of the smartphone divide. Our stratified region/school/class sampling scheme may have introduced confounding variables tied to particular schools tilting the results in unanticipated ways, and schools that opted in or opted out might introduce potential biases in either direction. Future research adopting both survey and other approaches (e.g., in-depth interviews and ethnographic research) should be invaluable in testing current patterns of findings, and more importantly, may identify other pivotal underlying factors shaping disparities in smartphone use.

6. Conclusion

As the smartphone consolidates its pervasive presence in most facets of everyday life, its role with and impact on diverse segments of society is an increasingly important question to address for researchers and practitioners alike. This is no exception for school-age adolescents. While individual circumstances and personal traits matter, environmental factors also notably shape smartphone engagement among this demographic. Geographic location (as manifested in metropolitan, mid-sized city, and small town/rural settings) is a significant contributor to disparities in adolescent smartphone use in China, and the multiplex nature of these gaps can be best dissected into the three levels as conceptualized in the digital divide framework: access (to different types of device, service, and content), skills and competence, and the associated negative and positive outcomes.

The research findings have practical implications for policy considerations with regard to reducing the smartphone-related digital divide among grade schools. Regionally structured gaps may be mitigated by tailored smartphone literacy educational programs proactively addressing skills and competency needs for students in certain regions, and educational resources can be mobilized and learning modules be created in catering to the specific needs of schools and students at different age groups in different geographic locations.

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Conflict of Interests

The authors declare no conflict of interests.

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About the Authors

Huan Chen is a PhD candidate in the School of Communication at the Universiti Sains Malaysia (USM). She is an associate professor in the School of Journalism and Communication at Minjiang University, China. Her research specializes in rural communication, new media technology and management, and visual communication.

Zixue Tai (PhD) is a senior faculty member and sequence head of the Media Arts and Studies program in the School of Journalism and Media at the University of Kentucky, USA. His research interests primarily focus on new media technology and applications in China, with a particular emphasis on social media and digital games.