



# An Upward Spiral Model: Bridging and Deepening Digital Divide

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**Abstract.** The digital divide is a global problem that impacts an individual's ability to participate in society. To address disparate and conflicting theories on the dynamics of the digital divide, the researchers proposed an integrated upward spiral model that explains how digital divides are both alleviated and deepened. The researchers then utilized an existing 2014–2015 dataset comprised of 398 survey responses and nine interview responses from Chinese migrant workers to test the viability of this model. Two hypotheses suggested based on the upward spiral model were supported by path analysis and supplemental qualitative analysis of the data: 1. A path traced causal relationship exists among forces, resources, access, e-acceptance, and e-inclusion and 2. Situational e-inclusion initiates forces, which in turn facilitates resources and access, and prompts ongoing cycles of situational e-inclusion. The results support that a comprehensive upward spiral model can be utilized as an analytical framework to explain the reasons and extents to which the digital divide phenomenon exists in society.

**Keywords:** E-inclusion · Upward spiral model · Deepening digital divide

## 1 Introduction

Although there has been remarkable mobilization in global ICT investment and infrastructure, the digital divide problem has not been eradicated. Rather, it is widely accepted that this complex and dynamic issue continues to evolve, particularly as ICT advances [1]. The digital divide remains an important challenge for policy makers, practitioners, and researchers worldwide [2]. In order to investigate the complexities of the digital divide, a thorough and dynamic understanding of the problem is necessary.

The digital divide has been widely addressed by researchers from various disciplines. This interdisciplinarity has resulted in longstanding dichotomies and, thus, a cluttered field. As such, researchers have called for comprehensive theories on the ICT inequality [1, 3]. In response, we proposed an integrative model, based on a synthesis of literature spanning 20 years, that includes both measurements and causes of the digital divide [4]. To further explain our conceptualization of the digital divide, we designed an upward spiral model and then tested its viability using empirical data on Chinese migrant workers' ICT experiences.

## 2 An Integrative Model of Digital Inequality

Ongoing revisions of our original conceptualization [4], resulted in a more succinct model (as seen in Fig. 1), where digital divide and e-inclusion are regarded as juxtaposed concepts that represent actual and desired situations in terms of digital participation. E-inclusion is attained only when “the effective participation of individuals and communities in all dimensions of the knowledge-based society and economy through their access to ICT” is equally achieved [5]. However, as long as people are excluded from digital participation at any level (e.g., political, social, economic), a digital divide exists. While digital divide and e-inclusion constitute effect measurements of ICT use, e-acceptance is the behavioral measurement that influences elements of initial adoption and continuous use [6, 7].

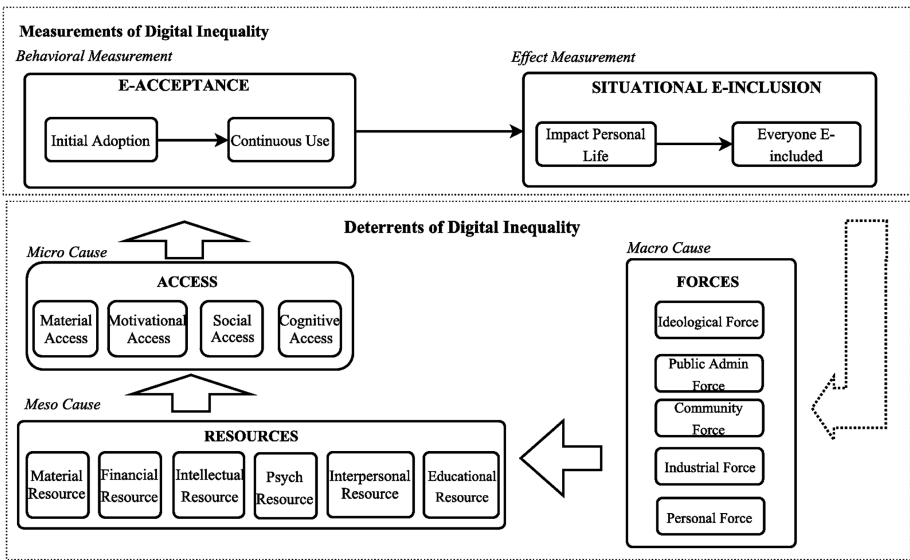


Fig. 1. An integrative model of digital inequality

Access, resource, and force describe micro, meso and macro determinants of digital inequality, respectively. Access denotes to the totality of an individual’s ability to readily use certain technologies in specific scenarios [8]. Based on the research canon, the various types of access include material access (e.g., computing devices, Internet connectivity, software), cognitive access (i.e., ability to use technology for various tasks), motivational access (i.e., desire to adopt, purchase, use, or learn technology for specific situations), and social access (i.e., socially-constructed conditions necessary for task-specific use). In contrast to access, resource is defined as available assets (e.g., money, equipment, knowledge) that can be drawn on by end-users to achieve access and actualize general technology use. Six types of resources have been found in previous literature: financial (i.e., available monies for ICT use), material (i.e., available

and affordable digital devices, infrastructure, and services for users), intellectual (i.e., general literacy, numeracy, and intellectual abilities related to ICT use), educational (external information, knowledge, and training materials or programs), psychological (i.e., psychological elements reifying motivational access), and interpersonal (i.e., interpersonal networks and social capital who promote ICT use). Different from access and resource, a force represents a higher order influential power that can directly or indirectly influence the structural, quality and quantity distribution of resources for ICT use and empowerments. Previous research substantiates that forces are ideological (i.e., influences from value systems or principles shared by mainstream society), industrial (i.e., influences from ICT vendors, ICT industries, and markets), public administrative (i.e., influences from municipalities, universities, libraries, etc.), community (i.e., influences stemming from local communities), and personal forces (i.e., influences associated with individual agency).

According to the model, forces distribute the necessary resources to supply individuals with multidimensional access, resulting in behavioral use of ICT (e-acceptance) as well as critical effects (e-inclusion). Those critical effects (e-inclusion) might reinforce the power of certain forces, resulting in another cycle of e-inclusion (as shown in the dotted lines in Fig. 1). Hindrances at either the force, resource, or access levels will lead to problems with e-acceptance and e-inclusion, resulting a digital divide.

### 3 An Upward Spiral Model of Digital Inequality

E-inclusion describes an ideal situation where all governing agencies support ICT use in all communities, granting each individual equal access to computing technologies and full participation in the digital society. The digital divide problem continues to deepen partly because e-inclusion is an ever-changing goal that coincides with the rapid evolution of computing technologies. Individuals may make adequate use of *specific* facets of ICT, which is referred to as *situational e-inclusion* (e.g., e-included in social media). However, as new technologies develop, new situations of e-inclusion sprout (e.g., e-included in virtual realities). The trajectory towards e-inclusion can be presented as an upward model as shown in Fig. 2. In the model, e-inclusion represents a phenomenon involving an infinite progression of forces, resources, accesses, e-acceptance and situational e-inclusion. The upward path denotes the ongoing levels of ICT engagement for individuals. However, individuals can either progress or become stagnant and eventually regress. According to the spiral model, situational e-inclusion is only achieved when everyone is e-included in specific technologies. Since technologies are evolving, there are infinite situational e-inclusion scenarios. Plus, people are situationally e-included at differing paces. Although a society may see gains in one type of situational e-inclusion, another aspect might remain unbridged. For example, although telecommunications infrastructure has promoted Internet use for millions of people in developing countries (e.g., one type of situational e-inclusion), poor economies and education inhibit the more advanced Internet use (e.g., another type of situational e-inclusion). Despite gains made related to bridging the divide, ICT continues to morph. This model helps to explain the ebbs and flows of the digital divide phenomenon.

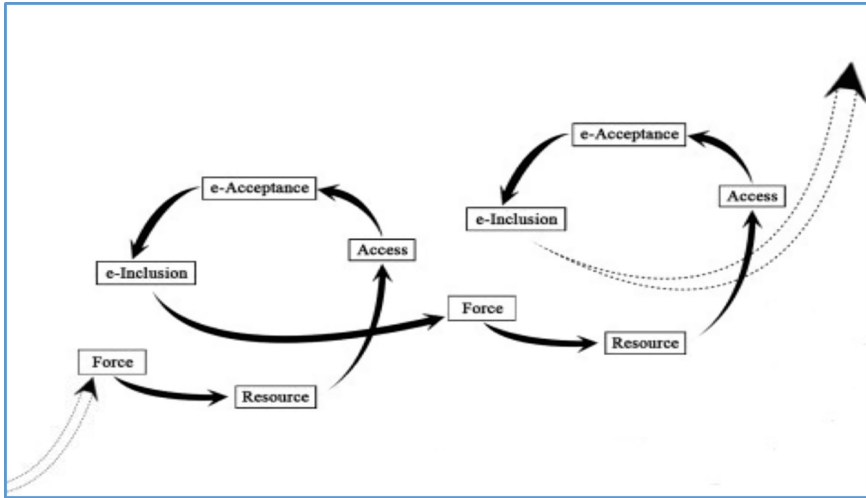


Fig. 2. An upward spiral model: bridging and deepening digital divide

## 4 Testing the Model

Based on the integrative model and the spiral model, the interactions among forces, resources, access, e-acceptance, and e-inclusion can be presented in the following two hypotheses:

Hypothesis I: A path trace causal relationship exists among force, resource, access, e-acceptance, and situational e-inclusion. Specifically, forces distribute resources, which impact access and facilitate e-acceptance and situational e-inclusion.

Hypothesis II: Situational e-inclusion can reinforce the power of forces, which in turn facilitates resources and access.

To test above two hypotheses, we used an existing dataset of computing technology experiences among Chinese migrant workers. Chinese migrant workers are those who temperately leave from rural regions to fulfill low-level jobs in urban areas. Since they are marginalized groups in China, they are considered more susceptible to the digital divide in comparison to dominant groups [9]. This dataset included 398 effective survey responses and 9 interview responses collected in 2014 and 2015 throughout China. Path analysis was applied to test the hypotheses and was analyzed using AMOS v.24, while content analysis was utilized to examine interview data that was organized using NVivo v.11. Codes were drawn from model constructs which were based on prior literature. We then investigated possible causal relationship between constructs. Two researchers achieved 0.71 Cohen's Kappa coefficient score for the qualitative analyses, and discrepancies were discussed with a third researcher until final agreement was achieved.

### 5 Preliminary Findings

The data supported Hypothesis I for all five forces. Various scenarios indicated a significant relationship linking forces to resource, and then from resources to access, e-acceptance, and situational e-inclusion. As demonstrated in Fig. 3, for instance, the public-administration force (i.e., influences stemming from governing bodies that effect changes in policy and public services) appeared to influence resources: Rural areas usually invest less and have inadequate broadband infrastructure. Poor ICT development negatively impacts ICT use and effects for local people. As seen in Fig. 3, path analysis results ( $df = 3$ , Chi-square = 3.758, RMSEA = 0.026, CFI = 0.998) suggest a trace path: big cities (i.e., public-administration force) provide better public broadband infrastructure (i.e., material resource), which led to suitable Internet connections (i.e., material access). This allowed migrant workers to significantly use ICT (i.e., e-acceptance), which positively impacted life domains (i.e., situational e-inclusion).

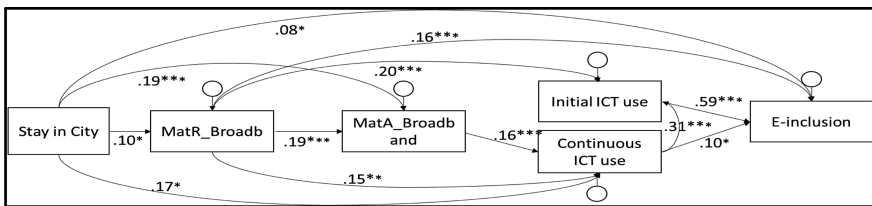


Fig. 3. Public administration force impacts preference between city or town and e-inclusion

Figure 4 showed the significant tracing path ( $df = 3$ , Chi-square = 2.315, RMSEA = 0, CFI = 1) of one type of personal force: monthly income of individuals. Likewise, higher incomes (i.e., personal force) allow for disposable income to purchase devices (i.e.,), which was in turn traced to the number of devices an individual owned (i.e., material access) along with their adoption rate (i.e., e-acceptance) and situational e-inclusion.

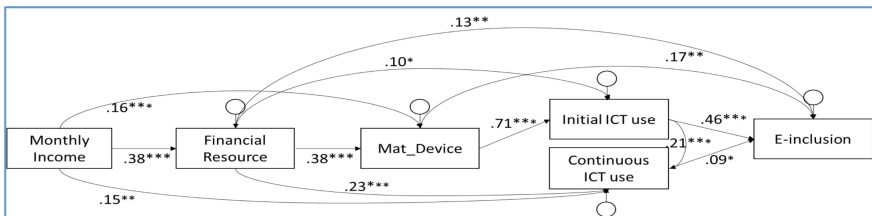


Fig. 4. The personal force impacts of monthly income on e-inclusion

According to Hypothesis II, situational e-inclusion can reinforce forces and subsequently advances situational e-inclusion. Therefore, e-inclusion is cyclical or iterative. Evidence of the spiral model was supported by the qualitative data; for example,

when migrant workers positively rated the impacts of their basic ICT use (situational e-inclusion, e.g., look for health information online), they were more likely to upgrade their devices or explore advanced ways of using ICT, thus initiating another cycle of situational e-inclusion (e.g., use social media to defend for personal legal right).

## 6 Conclusion

In this preliminary study, we proposed an integrated upward spiral model representing the dynamics of deepening digital inequality problem. Digital inequality can be measured according to behavior (e-acceptance) and effect (e-inclusion) in regard to technology use, as suggested by a trace causal path of force, resource, and access. The evolving technologies and technology use scenarios create infinite goals of situational e-inclusions to be attained. Further examinations of issues involving forces, resources, and access will help to diagnose and rectify digital inequalities. Since the analysis is based on secondary analysis of one existing dataset, more empirical data needs to be collected to test the viability and applicability of the model.

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