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SYSTEMATIC LITERATURE REVIEW OF LEVEL-ONE DIGITAL DIVIDE

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Abstract: Providing digital technology to every segment of society should be the prime concern of any government for society to be knowledge-rich rather than knowledge poor. From developed nations to developing nations, many are struggling to close the Digital divide gap existing in their respective society. The sustainability of the initiatives taken to resolve the level-one (availability) digital divide depends on the accuracy of the measurement. Previous research on technology availability has not taken a holistic approach of availability. This research intended to fill that gap by carrying out a systematic literature review of 100 research papers from 2005 to 2018 and 86 reports from 2010 to 2018. The findings indicate that while physical availability of digital devices and infrastructures are important, the technical support, capacity of the hardware and the autonomy to use when needed is equally important determinants of availability.

Keywords: digital divide, Technology Availability, Hardware Capacity, Autonomy, Technical Support, Systematic literature review

I. INTRODUCTION

When defining the digital divide, two questions arise; what is the type of communication technology taken into consideration? Where is the divide: socioeconomic divide or socio-geographic divide? Answering these questions is necessary as the type of technology measured differed in a different period and the causes, implications, magnitude, and initiatives to bridge the gap differs within and across countries as well. Thus, the digital divide definition has evolved over time and continuously changing due to the speed in emergent technologies. The Table 1 shows some of the definitions where availability of technology and the use of it is emphasized.

Table 1: Digital Divide Definitions

Reference	Definition
ITU, 2015	Digital divides represent the difference in ICT development within and between countries, regions, or socio-economic groupings.
ITU 2013, 2014	The difference in ICT access and use between countries, between regions, or between other groupings that share a common characteristic.
UNEGS, 2014	Ability to access and use ICT to promote well-being and prosperity
UN, 2014	The ability to access and use ICT to promote well-being and prosperity

Though digital divide has moved to level-two (use) the level-one (technology availability) issues persist, especially in the developing countries. Further, many researchers have not viewed availability in a holistic manner [1]–[8]. This research addresses the question:

What are the determinants of technology availability (level-one) in the digital divide?

For this, an evidence-based systematic literature review method was used to select the best research papers between 2005 to 2018. The evidence in this context is "synthesis of best quality studies on a specific topic" [9, p. 8]. The research scope is limited to education technology which includes personal

computers, notebooks, tablets, mobile computing devices, Internet access, Virtual Learning Environment, educational videos, and software for teaching and learning.

Figure 2.1 illustrates the digital divide research conducted in the seven regions. Global consist of cross-country research and the rest is specific to that region only. Regarding countries, the USA has the highest number of papers reviewed, followed by Global research – three papers concentrated in developing countries and fewer from South America, Africa and the Middle Eastern region.

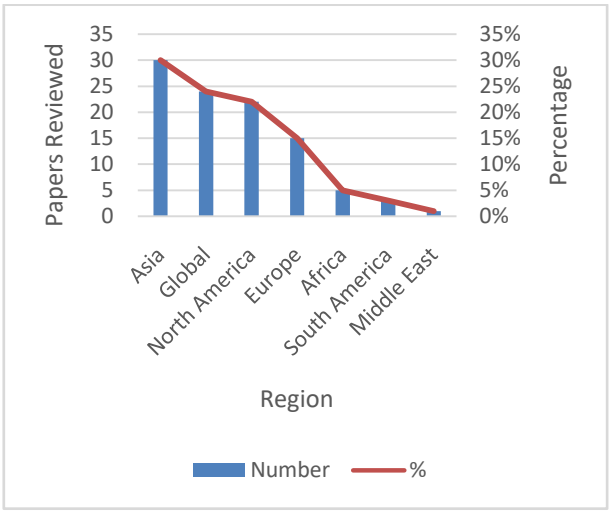

Figure 1: Reviewed Research Papers by Region from 2005 to 2018

II. OVERVIEW OF DIGITAL DIVIDE

In the 1930s, providing fixed telephone lines for everyone in the United States (US) was an issue. The Federal Communications Commission (FCC) was in charge of ensuring the availability of facilities for efficient residential telephone lines to all the people in the US at an affordable cost [10]. Thus, the term "universal service", popularized by AT&T president Theodore Vail, was used way back in 1907 when telephone service providers were primarily fragmented [11].

Naturally, profit-oriented companies tend to concentrate their business activities at high population density areas, rather than low population density areas as operating cost increases, affecting profitability when subscribers are fewer in rural areas. As Riddlesden & Singleton [12] said, "distance has a vastly limiting effect on service provision". The universal service concept was to eradicate the disparity in the access to fixed-line telephone between urban and rural, enabling all citizens to have equal access to communication, from 35 per cent of households with a telephone to 94.8 per cent in 1990, narrowing the US telephone divide. In the case of Malaysia, the penetration was 8 per cent in 1990 [13] unveiling the geographical divide between developed and developing countries.

From fixed-line telephone, the world witnessed tremendous growth in the mobile-cellular subscriptions and mobile devices such as smartphones. In 2014, there were seven billion mobile subscribers, and 50 per cent of it was from the Asia-Pacific region [14]. Despite the phenomenal growth in mobile communications, ITU [15] reported that the disparity between developing countries, such as Africa having the lowest 69 per cent penetration, are lagging behind developed countries. The Commonwealth of Independent States (CIS), have the highest mobile penetration of 170 per cent, followed by America and Europe, reaching 100 per cent since 2012. For the year 2014, Malaysia enjoyed 143.7 per cent penetration, exceeding 100 due to multiple subscriptions.

When personal computers made their debut in the 1980s, possession of physical hardware became the focus of the Digital divide. Telephones require minimum skills to use and one can learn quickly, but computers at that time required higher-order skills as desktop computers, or personal computers used command-line interface (CLI) operating systems. End-users need to remember the commands to use applications. The early users, not surprisingly, were professionals and those who could get assistance to operate the computer. Later, Apple computers introduced Graphical User Interface (GUI) operating systems, making it much easier to operate computers than using CLI. Consequently, user-friendly computers fascinated the masses, increasing the demand, and at present, close to 2.63 billion personal computers are in use in the world [16].

After personal computers hit the household, the Internet technology used by scientist, military officials and educationist in the 1960s, stormed the world in the 1990s. Easy to use browsers, like Netscape, enabled business organizations to adopt the Internet, Email, and World Wide Web applications faster. The ITU estimates 2.7 billion Internet users, 41 per cent global penetration, by the end of 2013. Of this, 78 per cent are connected in the developed world, but 90 per cent are not connected in the developing world[13]. ITU also found Europe to have the highest Internet penetration of 77 per cent, while Africa is at the bottom having 7 per cent, exhibiting the cross-continent digital divide. The US Census Bureau found that 27 per cent of the 118 million households surveyed did not access the Internet from home[17]. Many cite various reasons for non-usage; lack of interest, the Internet at home seem to be unnecessary and costly Internet service [13]. Initially, people accessed the Internet mainly using dial-up services and later broadband services became widespread. From 2005 to 2014, fixed-broadband penetration in developed nations grew from 11 per cent to 27 per cent contrary to developing nations where the penetration was from one per cent to six per cent only during the same period.

Though wireless technology existed more than 150 years ago, changes in government regulations, improvement in transmitters, superior repeaters, powerful amplifiers and routers, and market applications shifted mobile communication from emergency service users such as firefighters, police to mass consumers[18]. Diffusion of wireless network and drop in hardware prices facilitated businesses to replace desktop personal computers with laptops, tablets, and smartphones. Deloitte [19, p. 6] quoted Forrester consulting survey of how 66 per cent of companies said the mobile application has increased "employee responsiveness and decision-making". With the advent of smartphones, wireless broadband developed

rapidly, with 6.5 billion mobile broadband subscribers by the end of 2014, making the Internet available anywhere, anytime. Again, one could see the digital divide in smartphone adoption, not only the possession of smartphones but also the usage, differed between developed and developing countries, among minorities and low socioeconomic status people [20].

Given the fact that ICT access across countries has a serious gap, access within the country is alarming as well, especially in developing countries. Having Internet access may not guarantee equal access and become informed users as not everyone knows how to use the Internet effectively in searching for information and other online services[21]. Undoubtedly, contemporary computers are arguably user-friendly with GUI applications and operating systems. Moreover, the arrival of the touch screen in laptops, tablets, and smartphones further made the devices much more user-friendly. Despite that, many sections in the community still find these computing devices to be complex requiring a level of knowledge and skills to use.

The ICT in 2001 and the ICT today, after eighteen years, has changed dramatically from the static Web 1.0 to the dynamic Web 2.0 and Web 3.0. While the opportunities to access technology have increased, the digital skills required to access have also increased. Thus, the digital divide seems to be never-ending phenomena as innovations require new skill sets and the same section of socio-economically disadvantaged people in developing countries are affected. Thus, Benjamin Compaine [11, p. 2] viewed the digital divide as "the perceived gap between those who have access to the latest information technologies and those who do not". While the economically backward countries are grappling with the availability and affordability of computers, the Internet, broadband and mobile phones, the economically well-off countries are grappling with the speed and quality of Internet access.

In the United States, 98 per cent of the population who have broadband access have either wired or wireless access, leaving only 2 per cent population (19 million Americans) living in underserved broadband areas[22].

Table 2.1 shows the summary of prior digital divide determinants from 2005 to 2018. Availability dimension (72 per cent) is the most researched area. Despite the number of research in the availability determinants, most of them deal with the physical availability of infrastructure and software only. Less research addressed the capacity, autonomy, support, and no research addressed all the four in totality.

Table 2.1: Summary of Prior Digital Divide Dimensions 2005 to 2018

Determinants	# of Papers
Availability	72
Physical	66
Capacity	16
Autonomy	6
Support	3

For the literature review, 86 reports from 2010 to 2018 were selected after going through 121 published reports from private, government and non-government organizations. It is evident that the previous research measure digital divide mainly by availability, the use of technology and the skills required.

III. THE FINDINGS

The current research in the digital divide has highlighted mainly the availability of affordable infrastructure as it is the cardinal prerequisite before one could adopt education technology [12], [23]. When one possesses a computer or similar hardware and broadband connection, that deems to fulfill the availability dimension of the digital divide[24]–[27]). NTIA [20]quoted the US Census Bureau that 11 per cent households in the US sited inadequate computers or not having a computer as one of the reasons for not using the Internet at home in 2012. In their conceptual model for understanding digital inequality, Hsieh et al.,[28] espoused availability as one of the behaviour control factors impeding use when needed. Their findings validate availability having a strong influence for the socio-economically disadvantaged. Equally, many other types of research find the lower economic class as a barrier to the availability of computers and the Internet [29]. The income of a person, the price of computer and data plan charges determines the affordability[23]. Also, Loo and Ngan [25] research on the geographical digital divide in China highlights infrastructure availability as a contributing factor in using the Internet.

ITU, in 2009, implemented the ICT Development Index (IDI) consisting of 11 indicators to monitor and compare ICT developments between countries. In that ICT Infrastructure has been used as one of the pillars in Network readiness index (NRI) to measure the degree of societal preparedness for the excellent use of ICT. It composed of five variables; Mobile Network Coverage, International Internet Bandwidth, Secure Internet Servers, Accessibility of digital Content and Electricity Production[30]. Network readiness of a country affects Internet usage. James, [31] disputes the accuracy of IDI in measuring the digital divide as he deems the Index is resorting to double counting of inputs (skills) and outputs by treating all variables equally. Alternatively, he suggested a new weighted method for ICT use, which is taking the three variables from Use and adding one (mobile service subscribers) from the Access category, justifying less weight for fixed and mobile broadband on the ground that basic level IT usage should be the primary goal for developing countries.

For the ICT equipment availability for household and individual, ITU [13] measurement is composed of radio, telephone, computer, and the Internet. The inclusion of telephone, fixed-line or mobile-line is considered being vital as it is the foremost favorite, affordable and relatively easy-to-use communication tool. Also, the telephone is fundamental for using Internet service via Dial-up-service, Integrated Services Digital Networks (ISDN), or Digital Subscriber Line (DSL) [13]. Further, ITU justifies radio inclusion in their index for its reliability, portability, and usability even without electricity, making it an essential medium of communication in the

developing countries, imparting education and health services to remote villages. In the case of television, the popularity of this medium is evident from its 80 per cent global household penetration by 2012 compared to 37 per cent global Internet access. The ITU index in its calculation assigns a weight for each technology. Hilbert [24]) sees the problem in the weighted method as the weights assigned are based on the researcher's discretion and does not determine the technology relevant to bridge the divide.

Out of the 100 articles reviewed in the systematic literature review, none included radio and television as a technology for their digital divide study. Srinuan [32], whose literature survey of 195 digital divide articles, spanning from the year 2001 to 2010, found the same on the technology equipment. This survey concludes that 73.3 per cent of the studies analyzed computers, Internet and Broadband only and the rest of fixed and mobile telephone, multiple ICT, and ICT indexes. These findings establish the need to identify the technologies to be included in the digital divide study. Hilbert [33] considers conclusion can differ on the digital divide based on the technology chosen as he puts it, "not all technological innovations are equal. Some have more capacity than others" (p. 20).

Guillén & Suárez [34] argue in their research that telecommunications policy and democratic space of a country determines the availability of ICT infrastructure for the Internet. Their data involved longitudinal dataset of 118 countries. Privatization, liberalization, and allowing more competition in the local telephone services increase Internet availability [26]. Further, Guillén and Suárez [26] assert that democratic countries have faster Internet growth than authoritarian countries like North Korea, Cuba, Myanmar, Vietnam, Middle Eastern countries and China, which controls the availability of physical access. In the same vein, Barzilai-Nahon [29], agrees on the availability of network and associated technologies are political in nature, indirectly affecting the digital divide index. However, the reliance on only publicly available data puts Guillén and Suárez [26] analysis to some limitations, and the question of democratic space can be subjective as can be seen in the case of Singapore which ranks eighth in the world in ICT availability [35], but arguably the country has limited freedom [36].

While Crenshaw and Robison [37] concur on democratic openness, they cite globalization, urbanization, and other factors are providing the right structural element for Internet diffusion in the developing countries. They used an example of how Nigeria, one of the world's most impoverished countries, had more than 90 Internet service providers and has more than 1800 Internet cafes in the city of Lagos to justify how urbanization offers an avenue for Internet growth. Their research, the change of Internet host between 1995 and 2000 for 80 developing countries, suggest an active role of politics in the availability of Internet facilities.

Democracy and freedom correlation to ICT availability received further support from Pick and Nishida [7] who postulate that "a democratic, free, and lawful society fosters more communication of ideas and collaborative activity" (p. 5). They argue that foreign direct investment in developing countries to be playing a crucial role in ICT availability in conjunction with tertiary education and judicial independence, which applies to developed countries as well. Wijers [38] research in Cambodia points to the political reality of the country for lagging on IT development and supports higher education to be a catalyst to bridge the digital divide.

From the above arguments, the unavailability of ICT infrastructure consisting of broadband, computers, Internet and software application hamper Accessibility, Use, and Appropriate Use. The physical availability of infrastructure and software is the most widely researched characteristic of Availability dimension in the literature.

Other than research published in journals and conference proceedings, many international and regional organizations also have addressed the Availability issue regularly in their reports.

3.1 PHYSICAL AVAILABILITY

From the macro point of view, Malaysia is a democratic country that does not restrict technology availability to the public [39] and targets 95 per cent of Malaysians to have Internet access and broadband speed of 100 Mbps for 50 per cent of urban dwellers and 20 per cent of rural dwellers[40]. The transformation from an agricultural nation to an industrialized nation[41], resulted in 73.6 per cent of Malaysians living in urban areas[42]. Urbanization, liberalization of industries and privatization of the telecommunication sector have increased infrastructure availability in urban areas but not equally in rural areas. For the economically disadvantaged community, purchase of hardware, software, and broadband access are still not within reach.

The Malaysian government in addressing the availability issue has set rules to ensure opportunity for every home to own a computer and ensure broadband services are available in rural areas, on the premise that greater availability could lead to greater use. Subsidies and limiting the number of Internet service provider licenses awarded enable telecommunication companies to be profitable [43], [44]. Eventually, these rules are supposed to increase availability in urban as well as in rural areas. However, in reality, these service provider's routine is to violate the rules by not setting up adequate infrastructure in rural areas[45]. The regulatory authorities' routine is also to close an eye on non-compliance as the owners of these companies are politically well connected[46].

Not only companies, but the people also have the habit of misappropriating funds, too. Employees Provident Fund (EPF) found that 66.5 per cent of those who withdrew from the fund was from the low-income group and many did not use the money to purchase a computer [47]. Also, the vendors chosen by EPF misused the scheme charging the customers excessively for a low configuration computer. The scheme to purchase computers from EPF ceased [48]. Thus, the initiative for greater availability is impeded again by unacceptable use.

Capacity

Although past literature has addressed the availability variable regarding physical access and possession, very few studies examine the capacity of technology equipment. The computer configuration such as hard disk capacity, processing power,

RAM, clock speed and monitor screen size can significantly affect the quality of using the Internet appropriately. Equally, the type of Internet connectivity makes a difference: whether it is dial-up Internet services, ISDN, DSL and wireless broadband. The demand for high-speed broadband connectivity has been increasing due to rich media services [12] such as video and music streaming, image uploading, and downloading require higher bandwidth resources. Speed can seriously affect availability during peak hours in densely populated areas.

Li and Ranieri [49] researched primary schools in China between urban and rural children adopting DiMaggio and Hargittai's [50] framework comprising five dimensions to measure the digital divide. Inequality is one of the dimensions identified, referring to the availability of high-speed computers and connections. Their questionnaire research, involving 658 primary students from four selected schools, supports the capacity of apparatus (computers and Internet) to have a significant correlation with the Internet self-efficacy [42]. Similarly, Hilbert [23] describes this divide, the availability of quality (capacity) computing and telecommunication facilities, as "technological information inequality" (p. 20) present in society perpetually. Also, he proposes to define the digital divide by the broadband speed of bits-per-second and to classify those who are below certain kbps to be in informational poverty.

3.2 SUPPORT

The technology availability depends on the level of technical support available for maintenance and troubleshooting. Merely supplying computers to school will not resolve availability issues as technology equipment are not durable and likely to be down without support and maintenance. Valadez & Durán [27] include the availability of support as one of the variables in redefining digital divide. He defines the availability of support "as the support for teachers to acquire the skills needed to integrate Computer and Internet in their classroom teaching" (p. 34). Their research finds no significant differences between high and low resources school in California owing to the funding from the state and the total support of local authorities for ICT integration in teaching. At the same time, they found significant differences in hardware availability in the six schools studied where high resources schoolteachers have more availability of computers and Internet connections. Similarly, Turkish primary school students who are from low socioeconomic level families have fewer computers than middle and higher socioeconomic level families [51].

According to a Gartner survey, hardware and software cost is only 20 per cent in Total Cost of Ownership (TCO). Administration cost such as training, maintenance, personal use of computers by the employees during office hours, evaluation, upgrades, power consumption, virus, auditing, and downtime accounts for 80 per cent (New Zealand Government, 2013). Failure to understand TCO results in under budgeting [52].

3.3 AUTONOMY

Adding to the support level and the capacity of technology for increased availability is the autonomy of use. The level of freedom to use computers and the Internet is an essential determining factor in availability. Having computers and Internet at home enables the freedom to use [49] whenever needed, unlike if one has to use it in the office or one has to go to cybercafes or libraries [50]. The US Census Bureau in 2012 found that 30 per cent of the 119 million households surveyed did not access the Internet from home. Lack of interest in the Internet, the perception that subscribing Internet services for home is unnecessary, and being costly to subscribe [53] are some common reasons cited for non-usage.

However, the advent of smartphones and mobile broadband explosion empowered users with anytime and anywhere Internet use. According to the U.S Census Bureau, 76 per cent of Americans had smartphones as of 2016, and 82 per cent of Americans had a broadband Internet subscription [54]. Equally, CPS research says 42 per cent of Americans aged above 24 surf the Internet using mobile devices in the year 2012. Though the mobile Internet has "skyrocketed between July 2011 and October 2012" [20, p. i], the new communication tool is widening the demographic gap [48]. Further, Lee et al., [1] research find fixed line users use the Internet less frequently than those having wireless availability. When it comes to hardware, the leading indicator for the autonomy of use in schools is the student-computer ratio [55], [56]. In China, Li and Ranieri [49] find that the availability of the Internet is better at home than at school.

IV. CONCLUSION

It is evident from the above literature review that the current definitions of availability dimension of the digital divide are deficient. Table 3.1 illustrates the definition of availability determinants.

Table 3.1: Level 1 Availability Determinants

Variables	Description	Source
Infrastructure and Software	Internet, Broadband, computers, mobile communications, and educational software's availability for a subscription.	Hilbert (2011); Loo & Ngan (2012); Srinuan (2012)
Capacity	The computer configurations such as hard disk capacity, processing power, RAM, clock speed and monitor screen size, and broadband speed.	Hilbert (2013); Ohiagu (2013); Li & Ranieri (2013)
Support	Maintenance and troubleshooting of hardware and software problems	Valadez & Durán (2007)

Autonomy	The level of freedom, convenience to use computers and the Internet.	Li & Ranieri, 2013; DiMaggio & Hargittai (2001)

The availability is the sine qua non before one can use computers. Greater autonomy leads to greater availability. Thus, autonomy here is the infrastructure and software availability at-home classroom whenever needed for students and teachers. As such, in the context of primary schools, this research defines availability as the obtainability of infrastructure and software that is uninterruptedly operational for teachers and students at their convenient location. The capacity of the hardware, including broadband speed, technical and application support, and the autonomy of use determine the actual availability rather than a mere presence.

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