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NTNU
Norwegian University of Science and Technology
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Department of Education and Lifelong Learning

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Consequences of Digital Divides on Children's Academic Performance

Master's thesis in Childhood Studies
Supervisor: Ursin, Marit
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Abstract

The global pandemic of novel coronavirus affected teaching-learning in schools for several months during 2020-2022. On one hand, this showcased preexisting socio-economic and digital inequalities across schools, communities, and regions, and on the other, increased children's participation in different digital environments. The evidence shows the *First Digital Divide* – inequality in digital access – is decreasing globally while the *Second Digital Divide* – inequality in skills and usage – is rampant among children in different contexts. This means that children's digital use is not homogenous, despite the universal identity of *Digital Natives, Net-gen, or Z-gen*. This heterogeneity in digital use has created the *Third Digital Divide* – inequality in outcomes – which again has profound social consequences beyond children's learning and well-being. This study examines this heterogeneity in digital use and its impacts on children's academic outcomes in Global North and South schools, which are explored in global research published between 2000 and 2020.

Using socio-material perspectives and notions of the ANT (Callon & Latour, 1981; Latour, 2005; Law, 1992) and a systematic review methodology, I synthesize 62 studies exploring dynamic relationships between the digital divide(s) and children's academic outcomes. Furthermore, I employ those analytical concepts to unpack various social and material aspects, called *actants* (e.g., family social, cultural and economic capitals, digital technology, learning spaces, platforms, materials, etc.), which seem to mediate the heterogeneous use of digital technology and create different academic outcomes.

The review suggests that children from disadvantaged families use digital technologies, mostly, for non-educational purposes, while their privileged counterparts employ similar platforms for information and learning. This is because the *assemblages of heterogenous materials*, consisting of both human and non-human resources, aggregate to help the privileged children successfully translate those means into academic achievements. These findings show that the "academic agency" is produced by heterogeneous materials rather than an individual child. Available empirical evidence supports this argument because academically poor-performing learners improved both academic and non-academic outcomes following the effective implementation and use of digital technologies. This warrants a shift in the understanding of academic performance purely as the cognitive ability to the outcomes of assemblages capitalized on children by themselves and others at their disposal. I conclude the study by suggesting that the socio-material perspective is compelling to integrate heterogeneous materials into our analysis, providing critical insights into matters that produce academic inequalities. This is significant for the field of *Childhood Studies* because children's learning experiences affect their development and well-being, which have profound consequences for neoliberal schooling and society. Thus, any effort towards improving children's learning experiences and outcomes needs to concentrate on the quality and sustainability of the assemblages in which children are embedded, which means providing children with ubiquitous access to digital technology is necessary but not sufficient condition to improve learning and well-being.

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List of Abbreviations

ANT – Actor-Network Theory

CAI – Computer-Assisted Instruction

ECD – Early Childhood Development

ECEC – Early Childhood Education and Care

ERIC – Education Resources Information Center

GPA – Grade Point Average

ICT – Information and Communication Technology

ITU – International Telecommunication Union

K-12 – Kindergarten to Grade 12 Education

OLPC – One Laptop Per Child

PC – Personal Computer

PISA – Programme for International Student Assessment

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses

SCOPUS – Abstract and Citation Database

SES – Socio-economic Status

STEM – Science, Technology, Engineering and Mathematics

UN – United Nations

UNCRC – United Nations Convention on the Rights of the Child

UNESCO – United Nations Educational, Scientific and Cultural Organization

UNICEF – United Nations International Children's Emergency Fund

UNSDG – United Nations Sustainable Development Goals

USA – The United States of America

WoS – Web of Science

Prologue

Molde, Fall 2021

When I engage in conversations with my sister in Suburban Nepal, I often find her bothered because her two middle-school children use mobile devices several hours a day. While those devices helped them connect with online learning environments when schools were shut down due to the novel coronavirus (COVID-19)[1], I am aware that many parents like my sister are concerned about the children's screen time along with the missed school days and the effects it may have on children's academic performance. My follow-up conversations with my nephews reveal that they did not succeed in maintaining their academic achievement on annual examination[2], and their parents and the school blame them for the poorer results.

After following these conversations and incidents, I remember how traumatised I had been when I had to repeat grade eight for yet another school year. The social consequences I experienced after failing the annual examination were more severe than the lost year, which are still vivid in my mind. Later, some important questions became recurrent in my thoughts: Why did the children experience the learning loss despite being connected to online/virtual learning managed by the school? How did exposure to different digital devices affect their academic performance? Could there be other factors which influenced children's academic attainment? Do children learn better when they get ubiquitous access to digital technologies? What are the consequences of using or not using digital technologies in children's formal learning?

On the verge of writing this MPhil thesis in Childhood Studies, I pondered the aforementioned issues and their implications for children's rights, learning and well-being in a wider context. Before problematizing these issues for the current study, I will briefly discuss and reflect on contemporary discourses about children and childhood. This will set the background of the study, which seeks to shed some light on pertinent sociological issues while realizing children's human rights in formal learning contexts.

[1] UNESCO (2022) reports schools in Nepal were closed for the total of 82 weeks during February 2020-July 2022.
[2] In Nepal, annual examinations are summative types, which usually determine class upgrading and provisions of school supplies. Thus, such results attract public attentions.

1. Introduction

In the field of childhood studies, there is a great deal of consensus in Philippe Ariès' articulation of childhood as a social institution (Ariès, 1965, 1982) that bears socially constructed meanings (Christensen & James, 2008; James & Prout, 1997; Montgomery & Woodhead, 2003), and social significance (Hendrick, 1992, 2008). This shows how childhood represents unique social, cultural, economic and political environments children belong to (James & Prout, 1997). Also, this entails a diversity of childhoods within the same generational cohort.

What is more significant is that childhood as a social structure or element shares dynamic relationships with other social elements; adulthood and old age (Alanen, 2009; Qvortrup, 2009). This unique space creates an opportunity for children as social actors, competent to negotiate social relationships and make rational choices to influence their lives and that of the others in their networks (James, 2009; James & Prout, 1997; Mayall, 1994). Children's active participation in dynamic relationships with different people (both intragenerational and intergenerational) sharing different social structures provides them with meaningful spaces to construct identities and to architect childhoods distinct to their contexts (Alanen, 2009; Mayall, 2002; Punch & Tisdall, 2012; Qvortrup, 2009).

However, "neoliberal narrowing of contemporary schooling" (Selwyn, 2023b, p. 13) shows that children's rights are often not contextualized but are globalized (Abebe & Bessell, 2011; Burman, 2016; Castro, 2021; Hanson et al., 2018; Liebel, 2020; Liebel et al., 2012). Children's rights discourses enshrined in the UN Conventions on the Rights of the Child (UNCRC, 1989) are a manifestation of such ideology enacted through domestic laws in countries in the Global North and the Global South alike. The locus of the problem is the conceptualisation of a homogenous and universal childhood in rights discourses that contradicts the cultural diversity and indigenous forms of learning (Hanson et al., 2018; Liebel et al., 2012). Scholars observe that neo-liberal market policies incorporated in the UNCRC have detrimental effects on children in the Global South, at least from children's perspectives (Abebe, 2007; Kjørholt, 2013; Qvortrup, 2009). Furthermore, enacted through economists and politicians, these policies have succeeded to manipulate educational institutions and parents making them value children's academic performance more than anything else they do (Qvortrup, 2009; Selwyn, 2023b). Likewise, growing international attention towards the results of standardized tests at different levels shows public interest in children's academic performance in favour of those who make it to the top rankings. Children's schoolwork is compared to both parents' and nations' market investments (Kjørholt, 2013; Qvortrup, 2009; Wyness, 2019).

While it is true that excellent school grades often turn profitable in terms of a scholarship, tuition fee waiver or the like, children are valued and awarded in terms of

their prospects to be successful adults in future. I consider this future-oriented perspective problematic for at least two reasons. First, it values the (top/brilliant) 'becoming' child (Qvortrup, 1985, 2009), which focuses on (pursuing) ends, not means. This implies that children are neither valued for how they are learning nor respected as rights-bearing individuals at present. This is well explored in childhood research in the context of the Global South (see Devine et al., 2021; Kjørholt, 2013; Marshall, 2016). Second, "descriptions of children are often aligned with assessments, measurements, standardisations, normalisations, and judgements" (Oswell, 2013, p. 110). Children's grading based on their academic achievements (measured in Grade Point Averages/GPA or percentage) is not a new phenomenon in formal education. I am aware that when schools announce annual results at the end of an academic year, they categorise children according to academic rankings, which signifies some are brilliant while others are "brainless". This practice serves to abnormalize children who do not simply meet global norms and standards (Myers & Bourdillon, 2012). When some children's poor academic performance suffice to define their worth, they are nothing more than a cognitive entity (Ball & Collet-Sabe, 2022) for schools of today.

Following the school results, I have witnessed that children with poorer academic achievements get different forms of punishment from their teachers and parents, albeit prohibited by law. Subsequently, these children may experience social exclusions, bullying and mental health issues, all of which have wide-ranging consequences (Macrae et al., 2003; Wolke & Lereya, 2015). Paradoxically, schools may become agents of social exclusion (Balagopalan, 2022; Razer et al., 2013; Spark et al., 2019), and even sites for exercising violence (Espelage, 2018). Moreover, such scenarios show that children experience systematic violence institutionalized via different practices in schools (Francia & Edling, 2017). This sort of violence against (academically) disadvantaged children creates social, cultural, psychological, and economic burdens on them (Epp & Watkinson, 1997). Seemingly an inevitable agent in ensuring children's academic development, the school system might endorse systemic violence through different practices (Gådin et al., 2013).

Besides, both "global and local policy discourses naturalise underachievement as deficiencies in culture, 'parenting' and ethnic identity" (Devine & Luttrell, 2013, p. 243). These issues are empirically documented in light of social and cultural constructions of the schooling (Balagopalan, 2022; Varenne & McDermott, 2018), as well as social and clinical consequences of the school failure (Pezzi et al., 2016). High social expectations to excel academically seem to add unnecessary pressures leading to damaging effects mostly on disadvantaged and/or less resilient children who lack dependable social safety nets in need (Gilligan, 2000, 2007; Pearce et al., 2019). Results of the meta-analysis involving 62,298 students aged 12-26 years reveal that growing competition in high

stake examinations and the associated sense of school failure (poor academic performance and school dropouts) have been high-risk factors in suicidal attempts and suicides among children and young adults (Castellví et al., 2020). These findings are consistent with an earlier systematic review that reports a strong association between school dropout and mental disorders in adolescents (Esch et al., 2014). Overall, these empirical observations show that negative school experiences have adverse effects on the life and well-being of children (and young adults) in different contexts.

While (often) with good intentions – that provision of quality education increases employment and income prospects, investment in human capital enhancement, which Giddens (1999) calls the "Third Way", is primarily futuristic. It values "children as future workers, and investment in children [a]s an investment for the future" (Myles & Quadagno, 2000, p. 157). This is similar to the 'social investment strategy' (Esping-Andersen, 2002) that targets future outcomes in the costs of children's current well-being (Qvortrup, 2009). Furthermore, central to these strategies is the conceptualisation of children as mere objects of investments in opportunities to be exploited in the future (Kjørholt, 2013; Myles & Quadagno, 2000; Qvortrup, 2009). So, there are reasons to critique the legitimacy of investments in children that primarily values them because of their future productivity (Olk, 2009). To put it in other words, an ideology which argues that "children matter because human capital formation matters" (Myles & Quadagno, 2000, p. 166) ignores children's rights and well-being here and now. Besides, this ideology risks abandoning children who are challenged in different ways and simply cannot meet academic expectations. These pose serious ethical and moral challenges making it harder to justify investment logic from a children's rights perspective.

Children's school work in itself is a productive activity of self-qualification, which requires no further justification for why the children as well as their parents deserve remuneration and social provisions (Olk, 2009). As children are public goods (Folbre, 1994), it is a social responsibility to ensure children's best interests are met and rights are served to help them improve their experiences and life chances. When we value the "scholarization of childhood" (Olk, 2009), it is significant to understand children's structural conditions that create opportunities and constraints in their learning environments (Boyden & Bourdillon, 2014; Mayall, 1994), hence influencing their potential and agency (Woodhead et al., 2014; Wyness, 1999, 2015). This is significant because children's learning experiences affect their development and well-being (Boyden & Bourdillon, 2014). In the section to follow, I discuss digital divides as structural conditions that shape educational experiences and outcomes of the "scholarized" (Olk, 2009), "schooled" (Balagopalan, 2022) or "globalized" (Aitken et al., 2008; Ansell, 2017) childhood. When pursuing an "ideal childhood with appropriate maturity" (Zhang, 2021, p. 691) and cognitive efficiencies (Doyle et al., 2009; Penn, 2011), we often overlook

children's sociocultural, economic and material realities that shape their learning experiences and outcomes (Bennett et al., 2008; Woods & Hammersley, 2017). Nevertheless, these issues have come to the forefront as schools have accelerated digital learning with the insurgence of the pandemic (Ayllón et al., 2023). Yet, a significant number of children are deprived of sufficient digital access. Thus, I present the scenario of digital exposure among children and discuss how such exposure might both contribute to and hinder their learning, agency and rights.

1.1 Children and Digital Divides

Children and young people born in the late 1990s and after are popularly considered "digital natives who think and process digital language fundamentally different from digital immigrants, their predecessors" (Prensky, 2001, p. 2). Access to the internet and different digital technology from early childhood has provided them with new identities (Weber & Mitchell, 2007) such as Z-generation (Amiama-Espaillat & Mayor-Ruiz, 2017), the net-generation (Hargittai, 2010), the techno-savvy (Combes, 2012) and digital generation (Buckingham, 2007; Montgomery, 2007). Researchers, however, observe that children's digital behaviours and experiences are not universal, but are widely influenced by different socio-economic, demographic and cultural factors (Livingstone & Helsper, 2007; Scolari, 2019; Selwyn, 2009; Stoilova et al., 2021). Inequalities in these spheres have played roles to create a grave inequality of digital access or connectivity among children in different regions of the world. As shown in the figure below, most children in European countries are connected to the home internet, while the majority of their counterparts in Africa are deprived of such access. The same applies to children in low-income, upper-middle and high-income countries (ITU, 2022).

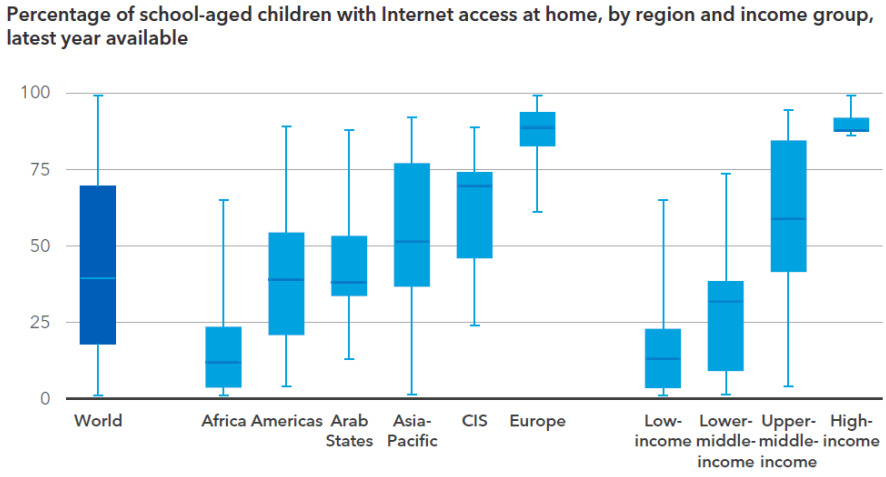

Figure 1.1: Inequality of the internet access around the world (ITU, 2022)

Seemingly close to its saturation in Europe with an average of only 5.4 % disconnected children, there are disparities among these countries as well, as Romania

(23.1%) and Bulgaria (20.8%) host the most digitally deprived children in this region (Ayllón et al., 2023). These figures add to the total of 60% of school-aged children worldwide who are excluded from the digital connectivity (ITU, 2022). This divide based on unequal access to digital connectivity called the *First Digital Divide* (Attewell, 2001; Van Deursen & Helsper, 2015) has roots in preexisting inequalities in society and between societies (Dimaggio et al., 2004; Roberts & Foehr, 2008). In other words, different micro-and macro-structures related to children determine whether they can enter the digital world. Even if children do so, their skills, motivation and engagement with different digital tools and resources differ significantly (Livingstone et al., 2019). Scholars argue that children with lower social and cultural capital and resources demonstrate scarce motivation to adopt sophisticated technologies (Bucy & Newhagen, 2004; Katz & Rice, 2002), which would otherwise support learning and skills development in times of global educational race (Sellar et al., 2017; Sjøberg, 2017) and hypes of the 21st-century learning.

While there are inconsistencies and conceptual unclarities concerning the content and characteristics of the 21st-century learning frameworks, digital skills seem to be necessary ingredients in them. These include various instrumental/ operational skills, informational skills, strategic skills, and social and safety skills (Iordache et al., 2017; Li & Hu, 2020; Van Dijk, 2006, 2013). Significantly, these skills and competencies have been integral parts of global education policy and practice, partly in response to digital "innovation" in different sectors and demand for skilled human resources and partly due to the pressures for learning recovery after the pandemic (see Patrinos, 2022, 2023). In fact, prolonged school shutdowns during 2020 and 2022 have created a learning crisis among children, widening pre-existing learning gaps between privileged and underprivileged groups in both Global North and South (Azevedo et al., 2023; Cheshmehzangi et al., 2023; Imchen & Ndem, 2020). In addition, as children bring an unequal set of skills and efficiencies into digital platforms, they create unequal opportunities in their lives (Livingstone et al., 2019). These variations, known as the *Second Digital Divide*, provide children with different identities as consumers ("cannots") and producers ("cans") in which the latter entails active and creative usages of digital technologies (Dolan, 2016; Van Dijk, 2013). These contrasting identities are also associated with contrasting impacts on children's lives beyond the school (Van Laar et al., 2017).

Similarly, recent findings show that children experience inequalities in outcomes as a result of their digital participation and usage of different resources available to them (Van Dijk, 2020). In literature, this inequality of digital outcomes is conceptualised as the *Third Digital Divide* (Van Deursen & Helsper, 2015). Again, socio-economic disparities produce unequal opportunities for digital capital, which seem to impact different forms of

offline capitals (Calderon Gomez, 2021). When "those who have greater digital capital are more likely to convert their digital self-efficacy into economic, social, cultural, personal and political capitals" (Ragnedda, 2017, p. 90), access to digital technology alone does not seem to improve learning experiences of the underprivileged children. Moreover, when different forms of capitals interplay with the quality of digital experiences and outcomes, even ubiquitous access to the internet and different digital technologies do not seem to improve educational outcomes among underprivileged children (Camerini et al., 2018; Dolan, 2016; Van Deursen & Helsper, 2015). A recent systematic review shows that teenagers' digital skills mirror digital and social inequalities, mediating various outcomes including academic grades and creative production of digital contents (Livingstone et al., 2021). These shreds of evidence help to make intellectual guesses concerning the educational and social consequences of digital inequalities, albeit outcomes in one platform do not necessarily translate to another platform (Helsper, 2021). Nevertheless, the implications of digital divides cannot be undermined in the information society.

In short, dynamic relationships between the *First Digital Divide* (unequal access to digital connectivity) and the *Second Digital Divide* (gaps in skills and usage) create the *Third Digital Divide* (disparities in both digital and offline outcomes). Scholars argue that this latter-mentioned divide poses serious challenges while the global community aspires to recover learning loss caused by the pandemic, decrease learning poverty and improve learning outcomes in elementary and secondary (K-12) education (Azevedo et al., 2021; Blikstad-Balas et al., 2022; Patrinos, 2023). These aspirations are well-formulated in global education policies and enacted through different acts and laws in the global context (Azevedo et al., 2021; UNICEF, 2021). In the sections to follow, I attempt to draw on the United Nations Sustainable Development Goal (UNSDG) 4(a): "Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all" (UN, 2015, p. 19). This is relevant to discuss how the verbs "build" and "upgrade" are translated into education practices and whether they seem to create opportunities while "striving" to ensure effective learning outcomes, as mentioned in UNSDG 4.1 (UN, 2015).

1.2 The Problem Statement

While it is yet to be observed how the UNSDG 4 upgrades education by 2030, independent scholarly observations show that the rhetoric of techno-solutionism has guided education policy and practice (Hardwick, 2021; Selwyn, 2023a). Contemporary education policies in the countries of both the Global North and the Global South reflect the spirits that more technology brings more learning in the classroom (Reeves, 2009; Roumell Erichsen & Salajan, 2014; Salajan & Roumell, 2016). Schools in different global

contexts, particularly, in low-income societies, have implemented different local and transnational interventions and initiatives, such as One Laptop Per Child (OLPC), Computer Aid International, Classmate PC and World Computer Exchange. Such programmes and funds from different donor agencies and IT companies provide schools with logistics and financial support to integrate digital technologies in classrooms. Though these are positive efforts in the education sector, empirical observations demonstrate polarized findings concerning sustainable learning outcomes in technology-mediated learning environments. Moreover, these shreds of evidence show digital intervention is not necessarily upgrading learning outcomes among children. But the technological hype that it transforms conventional practices and democratizes learning modes and spaces (Abbott, 2001; Pedró & Scheuermann, 2009; Tyagi et al., 2019), continues to dominate children's lives both in school and at home.

In this spectrum, results from OLPC interventions are disappointing in different contexts (Beuermann et al., 2015; De Melo et al., 2014; Mo et al., 2013; Mora et al., 2018; Shah, 2010) with a few exceptions (Chang & Kim, 2009; Thapa & Sein, 2018). In addition, a review study of OLPC deployment shows some perceived rather than measurable academic improvements in children (Nugroho & Lonsdale, 2010). Likewise, two systematic reviews show positive effects of various mobile technologies in literacy and self-efficacy development and STEM[3] performance among 0-5 years young children (Herodotou, 2018; Xie et al., 2018). Scrolling touchscreen alone is reported to have positive impacts on early fine motor development among toddlers (Bedford et al., 2016). Conversely, a realist synthesis conducted by Comi et al. (2017) confirms "ICT per se is not necessarily beneficial for student's learning" (p. 36). Surprising are findings that show increased PISA[4] scores (in reading, mathematics and science) linked to the intensity of gaming activities but decreased scores along with teenagers' increased involvement in curricula-related activities using a computer (Biagi & Loi, 2013). Through an idealist/narrative synthesis of 55 studies, Boyle et al. (2012) have also reported that digital entertainment games result in positive cognitive and psychosocial outcomes among children and adolescents. By updating the review of Boyle et al. (2012), Boyle et al. (2016) further claim that digital simulation games have positive impacts on learning in Health and STEM-related subjects. Otherwise, poor performance in the latter mentioned subjects, the so-called difficult subjects is a challenge, particularly in learners from rural and low socio-economic schools and family backgrounds (Murphy, 2021). Likewise, a recent qualitative review concludes that the use of an educational technology application produces measurable benefits in learning literacy, primarily vocabulary and comprehension development among preschool and elementary children (Eutsler et al.,

[3] STEM subjects include Science, Technology, Engineering and Mathematics.
[4] PISA stands for Programme for International Student Assessment.

2020). Booton et al. (2021) also report consistent findings concerning the impacts of mobile applications on basic literacy and language learning. These empirical findings show scholarly interest concerning the use of different digital technologies and their implications for children's academic development.

Besides, a review study conducted by Dolan (2016) claims rampant digital divides among K-12 students in the USA, suggesting that students belonging to the lower socio-economic strata have limited opportunities to benefit from the creative usage of various digital technologies. Similar are the findings among Taiwanese students who disproportionately rejoice in digital capital that corresponds to the family's cultural capital (Meng & Hsieh, 2013). These findings along with results from a longitudinal study of 843 Italian-speaking students in Switzerland suggest that children having lower socio-economic backgrounds use digital technologies, mainly, for entertainment and communication purposes limiting the creative potential of access, which also has negative impacts on school grades (Camerini et al., 2018). While these empirical works provide valuable insights concerning the impacts of digital use on learning, these are dispersed and under-scrutinized from a sociological perspective (Jordan, 2020). The findings of individual studies often provide conflicting accounts that bear the limited potential to dismantle techno-determinism or techno-solutionism, which leads to poorly informed practices (Sætra, 2023; Selwyn, 2023a; Villanueva-Mansilla, 2016). In particular, the field of childhood studies lacks comprehensive knowledge about why some learners benefit from digital technology use while their peers experience learning loss when using similar devices and tools. The current study tries to build solid knowledge and fill this gap by reviewing dispersed interdisciplinary studies that provide insights into children's material conditions and how they influence children's agency and academic experiences in different contexts.

1.3 Objectives of the Study

The study's main objective is to synthesize and critically assess the digital divide research that has studied children's and adolescents' academic performance published between the years 2000-2020. In doing so, I aim to strengthen not just *symbolic and conceptual utilization* but importantly *instrumental utilization* of empirical research findings (Sandelowski, 2004, p. 1372) across fields and disciplines such as Education, Sociology, Anthropology, Geography, Childhood Studies and Youth Studies, Media Studies, and alike. By examining robust research from different geographical locations and contexts, the review seeks to provide critical insights into the beneficiaries of digital technology use and their various circumstances.

1.3 Research Questions

This systematic review study seeks to answer the following research questions (RQs):

RQ 1. What factors influence children's digital technology use and academic performance?

RQ 2. Which academic and non-academic learning areas are influenced positively and/or negatively by children's digital technology use?

RQ 3: Which group(s) of children acquire academic benefits from digital exposure? Why?

1.4 Significance of the Study

As discussed earlier, a digital divide is emerging as a new social problem with severe educational, social, economic and political consequences among a diverse population (Ragnedda, 2017). This phenomenon is claimed to have reciprocal effects with other capitals, like social, economic, and cultural capitals (Gomez, 2020). This suggests that prior inequalities reinforce digital inequalities serving the already privileged group in technology-supported learning environments (Selwyn, 2023a). School closures accelerated by COVID-19 and the subsequent online classes have revealed such disparities in different contexts. While there are mixed results concerning sustainable educational benefits of digital technology use, we do know from experiences and agencies that 'disconnected children' are deprived of learning opportunities (UNICEF, 2020, 2021), hence their rights to education, article 28 (UNCRC, 1989) and rights in education (UNICEF, 2021) were undermined during the pandemic. Significantly, both children's access to digital technologies as a medium to participate in provisional online learning in schools and vibrant learning platform for incessant learning in the future have social, economic and political consequences in their lives. However, there is a quest for new evidence on how the use of digital technology influences children's learning experiences and outcomes (Bower, 2019). The current systematic review of literature attempts to fill this gap and to provide social and educational policymakers and practitioners with critical insights needed to make 'evidence-based decisions' (Bettany-Saltikov, 2012) concerning digital practices in formal education contexts. Besides, the new knowledge might be significant to parents and guardians who lack critical insights regarding home internet use, which has varying impacts on children's educational activities and academic achievements.

1.5 Delimitation of the Study

While there exist disparities in the structure and organization of formal education within and between regions, the K-12 education framework largely communicates with

the public education offered to children in preschool/kindergarten to grade 12. Though K level has increasingly attracted policy attention also in the Global South, a larger share of the practice involves daily care and socialization opportunity for young children through play. Less or no focus on their academic achievements makes the case for the K-related evidence to be excluded from the present review. In addition, the literature review builds on only those studies that document the effects of the digital divide on children's academic achievements, school grades and performances. By digital divide, I mean to suggest various inequalities linked to the (not) use of different digital technology and media. For the current purpose, I use digital technology and digital media interchangeably. Besides, the review, to my knowledge, builds on independent studies which means that studies published by corporate authors are not part of the current review.

1.6 Structure of the Thesis

In the first chapter, I introduced the thematic area and established the purpose of the current systematic literature review in the field of childhood studies. This is illuminated considering ongoing discussions around children's (non) participation in digital environments and its causes and consequences in *scholarized* lives of the *globalized* childhood. Chapter 2 will discuss agency by drawing on the theoretical construction of socio-materiality, which seems promising to understand children's experiences and outcomes embedded in the *assemblages* of human and non-human elements, called *actants* (Callon & Latour, 1981; Latour, 2005; Law, 1992). Similarly, chapter 3 presents the review methodology including the details of various technical and procedural steps applied while selecting the most relevant studies for the review. Chapters 4 and 5 present analysis and synthesis, which by using the actor-network perspective will form the basis of the new knowledge discussed in chapter 6. In chapter 7, I reiterate significant insights as concluding notes for the study and present my reflections concerning both the implications and limitations of the study for the field of childhood studies and education.

2. Theoretical Framework

In the previous chapter, different anecdotes and scholarly observations have established that children's participation in different digital platforms, their use and outcomes are mediated by different socio-material aspects. This shows that various external factors influence children's capacity to make informed choices in digital platforms, which determine the quality of digital experiences and outcomes (Livingstone et al., 2021). It means children's relationships with those external factors determine their agency, reflecting the virtue as a relational and distributed (Abebe, 2019; Esser et al., 2016; Oswell, 2013; Wyness, 2015) rather than an unshared credit of an individual. In the sections to follow, I will discuss these facets of agency while establishing their application in the current study and beyond.

2.1 Nuancing Agency in Childhood Studies

The field of childhood studies has long recognized children as competent, rational actors capable of exercising their agency and making informed decisions in their daily lives (Corsaro, 2005; James, 2009; James & Prout, 1997). This school of thought is widely cherished in research and scholarship interested in children's rights in diverse contexts. Despite the intellectual recognition of agency as an analytical tool, earlier conceptualizations of the notion are less sensitive to external factors that influence an individual's capacity to act (see Sutterlüty & Tisdall, 2019; Valentine, 2011). This critique embraces broader social questions about power, structure and culture, which are significant constituents of the new paradigm for the sociology of childhood (Oswell, 2013; Prout & James, 2015). Moreover, this worldview recognizes the interdependence between such constituents and an individual's capacity/positioning in shaping each other in significant manners (Abebe, 2019).

The latter perspective is a lineal descendent of Giddens's sociological theory of structuration that reconceptualises individual and society as agency and structure respectively and suggests their interdependence discarding supremacy of one over the other (see Giddens, 1984). This dualism means structures influence human agency and humans reproduce and maintain practices as per the agency they are capable of exercising in their circumstances (Giddens, 1984). From this perspective, it could be argued that child-friendly school/home environments facilitate positive experiences and outcomes, which are also meaningful for these contexts.

While structuration theory identifies children as knowledgeable social agents, it puts forward the interpretation of agency as social universal, which as an analytical lens, is inadequate because the human agency does not exist in isolation, but in a network of relationships with materiality, cultural form and social technology (see Oswell, 2013; Valentine, 2011). This argument suggests that children's agency is neither individualized

nor static, rather it is social and dynamic that is negotiated with different social networks and relationships, and with cultural resources (Abebe, 2019; Oswell, 2013). Significantly, those capable of utilizing social and/or cultural capital at their disposal can ensure *transubstantiation,* whereby the non-material capital transforms into material/economic capital and vice versa (Bourdieu, 1986). This process of conversions (or reproduction) of capital(s), however, depends on how strategic and efficient individuals are in channelling their social energy with actions (Bourdieu, 1986). Again, this highlights the mediating role of external factors in the creation of new forms of capital that increase the possibility of succeeding not only in the formal education (Coleman, 1988) but also in (the intergenerational) social mobility (Behrman, 2019; Johnson, 2008; Scherger & Savage, 2010). The potential outcomes depend on how effectively individuals exercise their reflexive agency while utilizing diverse resources available to them. Scholars observe how children's dissimilar experiences concerning educational outcomes and life chances unfold in diverse structural contexts (see Becker, 2022; Breen & Goldthorpe, 2022; Brown et al., 2016; Halsey, 2013).

As discussed in the previous chapter, children share an increasingly complex relationship with digital media, changing both the nature and meanings of learning, communication, leisure activities and family and social relationships (Livingstone, 2002; Selwyn, 2014). Age, gender, and socioeconomic differences influence the diversity of digital use and outcomes, not only in the countries of the Global North but also in the Global South (Livingstone & Helsper, 2007; Selwyn, 2009). There is ample evidence in media, education and sociological studies that popular beliefs and discourses rooted in technological determinism, essentialism or reductionism undermine both the social and material realities that produce unequal terrain of opportunities and challenges with digital technologies (Nolan et al., 2022; Selwyn, 2012). Studies that warrant children as either full agents or passive victims of negative digital socialization lack critical insights necessary for policy reforms and practices (Orben & Przybylski, 2019). These contrastive schools of thought about the influence of digital participation narrow the understanding while assigning uncritical identities to children as protagonists and antagonists in digital environments. As a result, children's relational experiences with digital technologies struggle to be recognized (Nolan et al., 2022).

What remains critical is the understanding of why and how some children exercise greater agency while participating in digital platforms and benefit more from digital exposure compared to their peers in corresponding contexts. This necessarily leads to the exploration of assemblages and crucial factors that shape the agency of children formed, translated, and expanded by employing different human and non-human resources. How they might be personalized to avail social actors is a critical question, which I discuss using the analytical perspective of Actor-Network theory.

2.2 "Networked" Agency or Actor-Network Theory (ANT)

The conceptualizations of agency in actor-network are radically distinct from that of early conceptualization of the notion in childhood studies (i.e., individual agency), structuration theory (i.e., agency as social universal) or social agency as defined via Bourdieu's social capital. This distinction is marked due to a material turn (Oswell, 2013) in the conceptualization of the notion, which is defined and regulated by non-human elements, powers, hierarchies, and dissymmetry that are integral parts of the construction of the "social" force, web or network (Latour, 2005). This means conventional understanding of the social capital or agency is inadequate as an analytical lens, rather a new perspective of the concept i.e., "patterned networks of heterogeneous materials" (Law, 1992, p. 381) is sought in empirical works.

Proponents of ANT argue that dichotomies of the social/technical, human/animal and micro/macro are unprofitable in that all these elements are necessary components in making, but also defining the durability of a network of relationships with one another (Callon & Latour, 1981; Law, 1992). Callon and Latour (1981) identify the actor in the chain of associations made up of people (bodies) and materials:

> An actor (is) …any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own…by ordering the chronology of that element and assigning roles to them, …creates own spaces and values and that of the others in the game (Callon & Latour, 1981, p. 286).

This short extract speaks an epic about what might be counted as actors and how they might gain agency in them. To put it in words, it highlights the process of how an individual might increase his or her capacity to act with other elements of the larger network. From this lens, it can be righteously mentioned that agency increases as the individual builds on various elements of the social web consisting of humans and different materials, technologies, devices, tools and objects, all of which have agency (Latour, 2005). This does not suggest a technical determinism but recognizes transformative potentials of materials, which modify a state of affairs by making a difference in modes to help amplify actors (Latour, 2005). Besides those tangible resources, different rules, interactions and habits collaborate for a single will, which determines the "fate" of the actor (Callon & Latour, 1981). By this, it should be reasonable to commend that all social forces at the disposal of an individual act as a *one-man army* in each context, which resolves the degree of agency one can exercise. On one hand, it suggests the multiplicity of the social forces, and on the other, the unity of those assembled in one single undisputable, cumulative force operating to confirm the way actors experience their circumstances and outcomes of their actions (Latour, 2004b).

The current work benefits from some of the central tenets of the actor-network theory advanced by scholars including Callon (1984); Latour (2005) and Law (1992). First, the agency is distributed across *heterogeneous materials*, which means objects, materials and technologies too, have agency in them which are capable of transforming actions. Second is the idea of *generalized symmetry*, which means neither humans, machines nor any other elements of an assemblage are superior to another. The third aspect corresponds to the idea that any difference in the agency of an element is the *effect or outcome of interactions* with other human and non-human elements (hereafter actants) of the assemblage. This means durability or sustainability of interactions with heterogenous materials determine how powerful an actant could be in a particular situation. When materials shape the outcomes of practices in social situations, it is hard to disassemble those materials from the social (capital). Moreover, when dissimilar materials participate in and contribute to outcomes of practices, for example, social relationships, social change and the construction of knowledge and power (Callon, 1984; Law, 1992), it makes little sense to claim social capital as unique human-human relationships (see Bourdieu, 1986). What is more critical is the understanding of how continuity or displacement of interactions, goals, interests, motivation, access to technologies, external support and similar actants influence the transformation or outcomes (Callon, 1984). The process of translation as an analytical concept is useful to explain how some actors negotiate their relationships with other actants and accommodate to mobilize them to overcome different constraints in the course of actions (Muniesa, 2020). Data show the outcomes of translation, here the use of digital resources, depend on the mobilization of enrolled human and non-human actants including the quality of children's interactions with digital resources, educational supplies and learning materials.

In addition, the displacement of the enrolled actants brings about changes in the outcomes, which corresponds to the idea of agency as a relational and distributed virtue (Abebe, 2019; Law, 1992; Oswell, 2013; Robson et al., 2007). By using this socio-material approach to agency, I discuss how some children gain academic benefits from the use of different digital technologies while their peers in similar settings experience poorer performance when using similar devices. This perspective sheds some light on how dichotomies –children as active agents/passive victims in digital environments and children do improve learning when used/not used technologies, are far from children's lived experiences. By discarding technological determinism, ANT helps to understand various complexities and contextual factors, which mediate children's digital behaviours and their outcomes. Understanding children's outcomes from the complex network of relationships with "natural, discursive, collective and hybrid materials" (Prout, 2005, p. 81) is compatible with notions of ANT and the moral project of the new sociology of

childhood. As the paradigm builds on socio-cultural meanings of childhood, it seems to benefit from ANT approaches, which provide critical insights into a socially and relationally mediated agency, which cannot be argued as an essential quality of an individual child (Nick, 2001; Oswell, 2013; Prout, 2005; Valentine, 2011). This is in the same spectrum of thought that knowledge is not the cognitive quality of an individual, but the outcomes of material-semiotic in the particular setting (Latour, 1983). It is through the material-semiotic that actors are capable to translate their assemblages increasing efficacy and power in the work they do (Law, 2016). In this light, I used different notions of ANT aiming to probe different socio-material phenomena or ecologies of the assemblages (Blok et al., 2020), which enable or constrain children's possibilities for positive learning outcomes.

Previously, different research in the field of childhood studies and education have employed different notions of ANT and socio-material perspectives to explore how human and non-human actors shape children's experiences and outcomes. Sørenssen and Franck (2021) illustrate the roles of material actors (toys and makeup) in the enactment of social norms influencing children's actions and experiences in the Norwegian early childhood education and care (ECEC) settings. Similar perspectives have been employed to study children's agency, which is distributed across heterogeneous materials in their assemblages (Sørenssen, 2016; Sørenssen et al., 2019). Although the evidence is scarce in educational research, the field has documented the potential of applying notions of heterogeneous actants and assemblages to explore how computational agents shape learning practices (Leander & Burriss, 2020). These notions have been applied to study how learners enact new agencies through technologies in classrooms (Kumar & Tissenbaum, 2022). Besides the use of technology, a socio-material perspective is employed in classroom research to explore pedagogical and disciplinary implications of modern chairs designed to facilitate educational behaviours (Selwyn, 2023b). These pieces of evidence show growing scholarly attention to "the doings of material objects" (Sørenssen et al., 2019, p. 698), which is considered an ontological turn for the field of childhood studies (Spyrou, 2019) and education (Fenwick et al., 2015; Zembylas, 2017). These recent developments in research open spaces for alternative perspectives on the matters that matter in children's scholarized lives.

Though ANT both as the theoretical and methodological approach is employed often "to follow the actors" in the field, some reviews successfully utilize it in synthesizing the published research. For example, Burnett (2010), by using the ANT perspective, suggests that it provides a lens to "deepening our analysis" of technology and literacy practices in educational settings. Likewise, a synthesis of the literature on mobile learning documents that "ANT has the potential to refocus, reframe and problematise over-simplified black boxes of affordances for learning" (Wright & Parchoma, 2011, p.

265). These pieces of evidence suggest a review relevance of ANT, which supports the view that analytical concepts of "ANT can be used to illuminate the results from research" (Walsham, 1997, p. 477). This is supported by subsequent development in research in this area (see Fenwick et al., 2015). In this respect, what remains critical for the current empirical work is an attempt to provide alternative insights by "following the associations" (Latour et al., 2012) between various actants in children's assemblages and their academic achievements. This provides meaningful opportunities to understand "how children become one or the other through the capacities afforded to them by the heterogenous assemblages which form at particular times to enable or constrain what they can be" (Spyrou, 2019, p. 318).

The study documents the significance of employing ANT because it values children as actors while providing critical insights into how their academic experiences are mediated by interactions and associations in assemblages sustained by and for children. This is unique in the sense it discards any confirmative bias about children but helps to understand their experiences shaped by socio-material realities (Wright & Parchoma, 2011). Furthermore, generating insights about why some actors benefit more from the use of digital resources is the core of the review, which is compatible with notions of agency and ANT. By the very token, it is also possible to identify the robustness and dependability of the actants (i.e., technology, applications and programmes, previous experience, competence, social support etc.), and to provide reasons for children's learning outcomes that show hierarchies and inequalities in different settings. This goes parallelly with the understanding that although "actors are all isomorphic, … they end up being a different size because some have been able to put into *black boxes* more elements durably to alter their relative size" (Callon & Latour, 1981, p. 285). What remains the core of such understanding is a close examination of those boxes that create and reproduce asymmetries in children's academic lives (see Wright & Parchoma, 2011).

Some scholars observe that children's agency unfolds in a continuum rather than being constant in their lifeworld (Abebe, 2019; Robson et al., 2007). This means children's agency shifts as a response to changes in assemblages, which shape their experiences (Panelli, 2002). This response from children comes as deliberate efforts in processes of thinking and doing in different contexts, which are necessary elements of the actor-network (Valentine, 1996). Moreover, how children navigate through different social structures and norms and negotiate relationships with different actants determines what their experiences would be with digital technologies. These theoretical perspectives guide the examination of children's material realities, which shape their digital experiences and academic outcomes.

2.3 Conceptual Framework

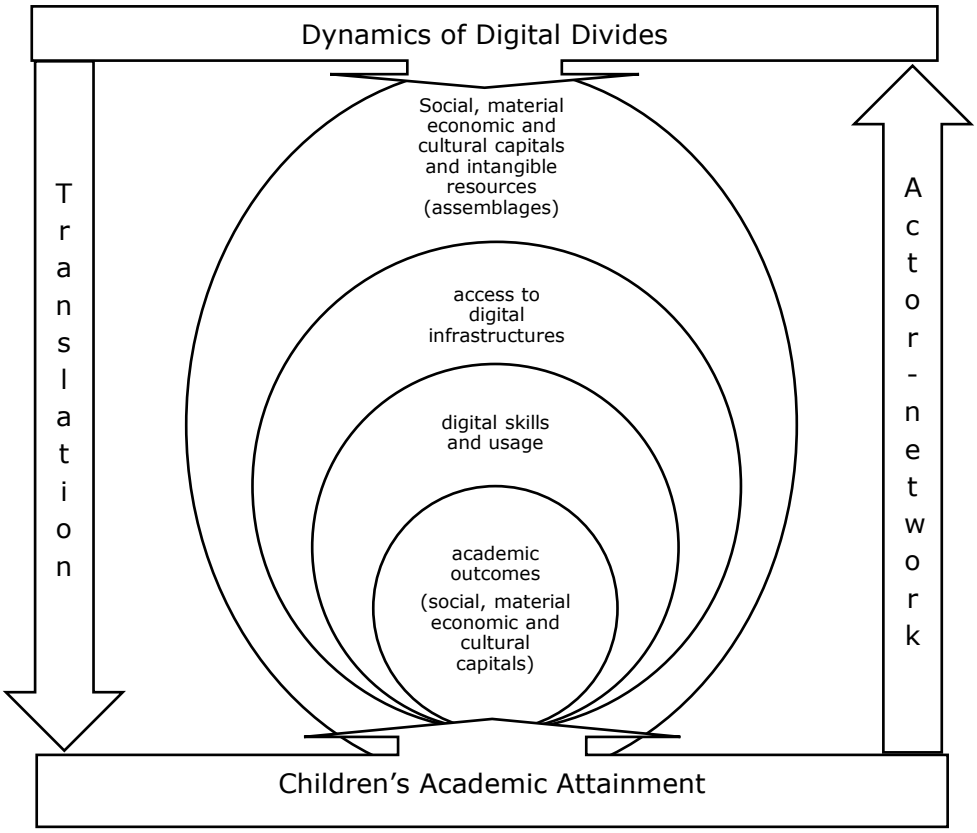

Figure 2.1: Conceptual framework of the review

The illustration of the conceptual framework (see Figure 2) is a visual representation of different analytical concepts introduced in earlier sections. In this illustration, I highlight the interrelationships among various actants like social, material, economic and cultural capital, digital infrastructures, interactions and engagement with the actants and their influence on children's academic attainment. Moreover, this shows associations between the actants and the potential outcomes of the network at children's disposal. In the sections to follow, I describe the review methodology and discuss the choice of different methods and strategies employed in the process.

3. Review Methodology

In this chapter, I present and discuss a detailed audit of what I did, how and why concerning the literature review. I have used some figures, tables, and charts to structure and concisely present information while providing transparent and detailed accounts where necessary. Significantly, the chapter presents the grounds of my knowledge claims to be discussed in the latter chapters. In the sections to follow, I briefly present those grounds under different sub-headings; review method, literature selection criteria, search strategy and procedures employed in the whole process of developing a coherent methodology.

3.1 Systematic Review Method

I used the systematic review method to synthesize knowledge developed by several primary research potent to enlighten current research questions (Newman & Gough, 2020). Moreover, the use of this method provided me with the opportunity to enrich current research questions with robust knowledge informed by diverse approaches and research methodologies. This plural perspective inherent in the review method has helped me to develop comprehensive insights into the study.

While there is variation in the practice of systematic reviews, I used aggregative and configurative synthesis. The former synthesis logic is used to analyze the impacts and effects of a phenomenon, while the latter helps to understand contextual factors that influence the impacts of the (digital) phenomenon (Newman & Gough, 2020). The use of these logics in the review process facilitated the selection and inclusion of primary research informed by realist and (critical) interpretive methodologies. This unique combination of different logics has contributed to generating in-depth understandings through primary research and benefitted from various methodological rigour. This suggests different qualities of systematic and emergent designs provide robust grounds for new insights that involve no or minimal bias (Harrison et al., 2020). In the following sub-sections, I present the entire review process and justify the use of procedures followed in the review.

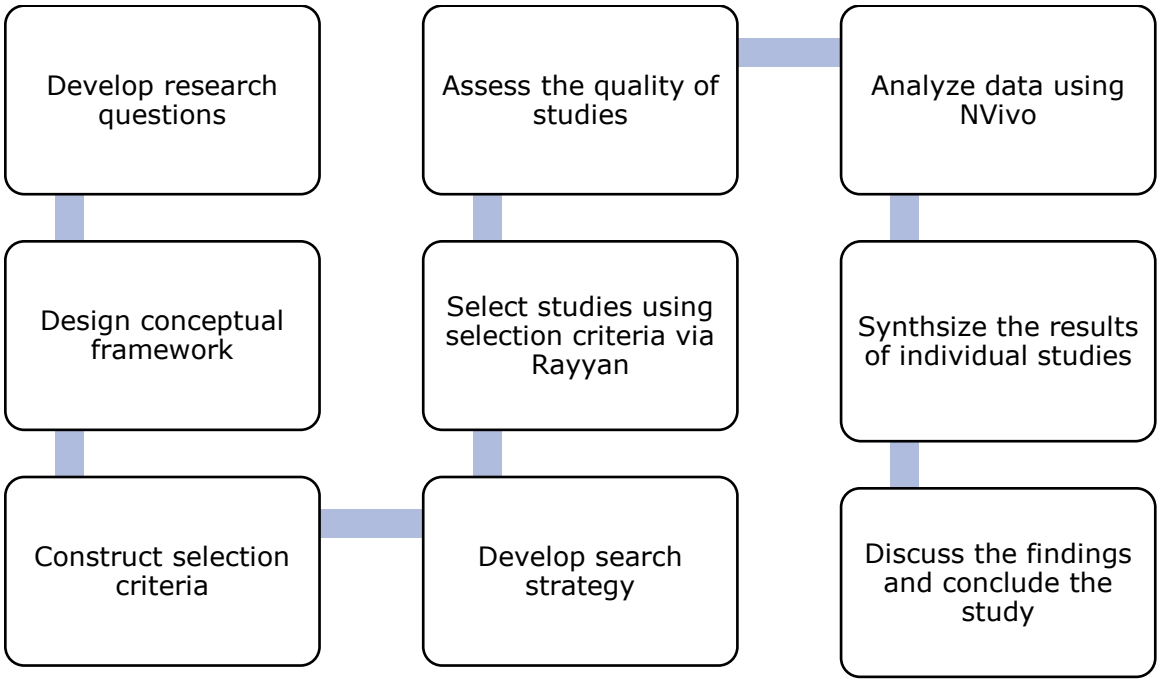

Figure 3.1: The systematic review process (adapted from Newman & Gough, 2020)

3.1.1 Selection Criteria

By adhering to the principles such as objectivity and transparency in systematic reviews, I rigorously worked to finalize inclusion and exclusion criteria. Preliminary database searches and a brief review of some relevant research helped me to decide on those criteria. First and foremost, the criteria of inclusion were based on research questions and a working title of the review, corresponding to the dynamics between children's exposure to digital technologies and their impacts on their academic performance. The rest of the study's qualifying criteria are presented in the table below.

Inclusion criteria	**Exclusion criteria**
Children and adolescents aged 6-18 years	Children below 6 and adults
Peer-reviewed, primary research articles	Documents, theses, dissertations, secondary research articles, reviews, opinion papers, conference proceedings, books and reports
Academic performance/attainment/ achievement or school performance	Non-formal learning or literacy practices outside the school
Measurable outcomes or results of (not) using digital assets in reading, writing, arithmetic, or any of the school subjects	Perceived outcomes, impacts or results Studies not identified as academic performance, such as learning motivation/interests and homework benefits and social skills

Publication range: January 2000-December 2020	All articles published before January 2000 and after December 2020
English language	All other languages except English
Grades 1-12 of K-12 Education/secondary education	Early grades/early-childhood education and development/pre-primary or kindergarten research, except longitudinal studies continued to primary grades
All study designs and methodologies	-
Global scholarship and	-
All fields and disciplines	-

Table 3.1: Study selection criteria applied in the review

3.1.2 Search Strategy

Based on the aforementioned criteria, the review followed the "three-tiered search strategies" (Aromataris & Riitano, 2014). First, a narrowly defined search, which I will present shortly, was carried out using the inclusion criteria in three databases which resulted in a total of 555 articles (SCOPUS 218, Web of Science 232, and ERIC 105). These references were imported into the EndNote reference manager and scanned through the 'find duplicate' option in the software. As a result, 119 references were removed, most of which appeared in ERIC and WoS databases that showed fewer datasets compared to references that appeared in SCOPUS. In the process of finding out the most relevant references, titles, abstracts and keywords of each included article were screened with the help of Rayyan. This web-based tool facilitated efficient reading and decision-making against previously specified inclusion and exclusion criteria. The table below shows the syntax used to produce the most relevant results while searching the databases.

Databases	Results	Search Queries
SCOPUS	218	TITLE-ABS-KEY((children OR adolescent* OR teen* OR boy* OR girl* OR (young people)) AND ((digital divide*) OR (digital deprivation) OR (digital diversity*) OR (digital inequality*) OR (digital stratification) OR (digital gap*) OR (internet gap*) OR (digital dividend) OR (ICT gap) OR (cyber gap) OR (digital exclusion*)) AND ((academic achievement*) OR (learning achievement*) OR (educational achievement*) OR (school performance*) OR (school achievement*) OR (academic performance*) OR (learning gap*) OR (academic success*)))
WoS	232	TS=(((children OR adolescent* OR teen* OR boy* OR girl* OR (young people)) AND ((digital divide*) OR (digital deprivation) OR (digital diversity*) OR (digital inequality*) OR (digital stratification) OR (digital gap*) OR (internet gap*) OR (digital dividend) OR (ICT gap) OR (cyber gap) OR (digital exclusion*)) AND ((academic achievement*) OR (learning achievement*) OR (educational achievement*) OR (learning gap*) OR (school performance*) OR (school achievement*) OR (academic performance*) OR (academic success*))))
ERIC	105	noft((children OR adolescent* OR teen* OR boy* OR girl* OR (young people)) AND ((digital divide*) OR (digital deprivation) OR (digital diversity*) OR (digital inequality*) OR (digital stratification) OR (digital gap*) OR (internet gap*) OR (digital dividend) OR (ICT gap) OR (cyber gap) OR (digital exclusion*)) AND ((academic achievement*) OR (learning achievement*) OR (educational achievement*) OR (school achievement*) OR (learning gap*) OR (school performance*) OR (academic performance*) OR (academic success*)))

Table 3.2: Syntax of search used in different databases

3.1.3 The Study Selection Process

Later, titles and abstracts of the 436 references were thoroughly scanned by the author, employing Rayyan which resulted in 66 references. Of the references, 62 open-access articles were short-listed and imported to the EndNote which facilitated access to and documentation of full-text articles. Although very limited articles were found via the "Find Full Text" option, the EndNote did certainly help to document the articles for recurrent use. The figure below shows the proportion of articles on the verge of making decisions for including and excluding them in the Rayyan.

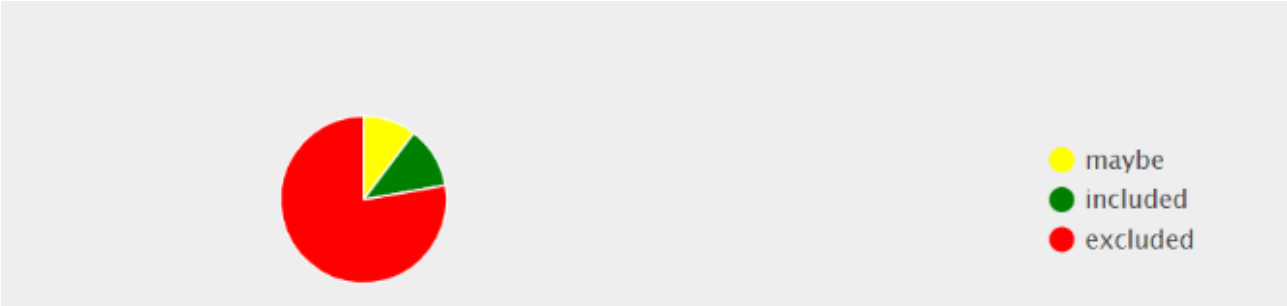

Figure 3.2: The first stage of inclusion decisions

While I did not struggle in finding the most or least relevant articles for the review, I struggled with a significant proportion of articles. This was particularly due to the inarticulateness of some titles and abstracts/summaries in research papers. Though it may be a strategy of the researchers who preferred not to reveal the crux at the very first page of their articles or a distinct intention, those were the articles demanding a thorough read, hence making the selection process more time-consuming. In Figure 5, the pie in yellow represents articles of similar nature. Revisiting those articles against pre-determined inclusion and exclusion criteria helped me to clear dilemmas and take informed decisions. While the pie in green represents included 15% of the total articles, the rest 85% demonstrates the portion of excluded articles. The figure below demonstrates the share of these references.

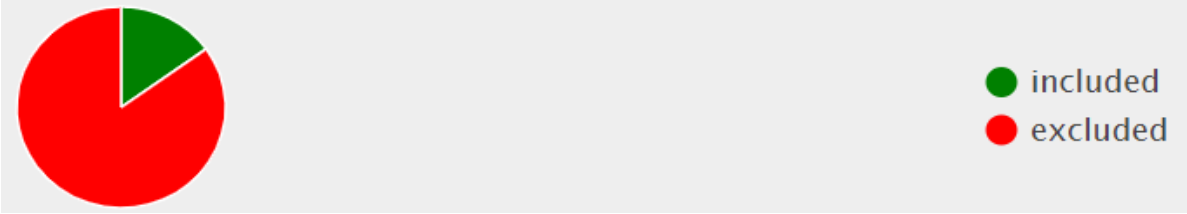

Figure 3.3: The second stage of inclusion decisions

3.1.4 Skimming and Scanning

As mentioned earlier, 62 of the total 66 articles available in full texts were considered in this process. While the skimming strategy helped me to get a general idea of the text, the scanning strategy facilitated my search for specific information in the texts. Using these strategies, I succeeded in finding articles of the research interest while narrowing the number of articles to be reviewed. The green portion in the figure below which covers only 43 articles was part of the final review process, which is approximately 9% of the total references found in different databases.

Figure 3.4: The third/final proportions of included and excluded articles

I am aware that these inclusion decisions comprise a significant part of the review methodology which help the reviewers to clarify how they succeeded to select very few articles among several hundred or thousands while ensuring reliability and validity in the reviews. The last decade of review research has witnessed the development of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) which help researchers "ensure transparent and complete reporting" in their reviews. I will discuss some relevant review qualities later. Now, I will summarize the inclusion decisions in the PRISMA flowchart.

3.2 Appraising the Quality of Studies

Even though I deliberately selected "peer-reviewed" and "journal articles" options during each database search, not all the studies that I screened were review worthy. Among those were the articles that insufficiently presented how methodological rigour was ensured in the study. While there is a great variation in methodologies used in the selected studies, I examined each of them against the research trend they employed. Studies that employed positivist paradigms, such as experimental and quasi-experimental studies were assessed against validity and reliability measures and study protocol as mentioned in individual research fields (Waddington et al., 2017). Similarly, a few studies that benefitted from mixed and flexible designs using interviews and observations, were assessed based on whether they practised reflexivity while implementing the design and reporting results as well as their relative contribution to the field (Carroll & Booth, 2015).

While it is not uncommon to observe contested opinions concerning criteria for critical appraisal, the practice of negative case analysis was significant also for this review (see Morse, 2015). I followed the view in the sense that reviews built on less or uncritical research might endorse false realities. This applies more to the intervention-related studies that often represent the interests of all, but hardly the people in need of a reliable medium to raise their voices. To address this issue, the current study has excluded research carried out by/for corporate agencies and organizations. Besides, I also discussed my assessment of the literature with my thesis supervisor and a PhD

candidate, who is familiar with the theoretical and methodological approaches employed in the review, to increase the review's validity. I believe these considerations in the review process contributed to adhering to academic integrity.

The PRISMA-Flowchart presents an overview of strategies applied to identify, assess, and reduce the bulk of studies into a manageable review size while including the most relevant contributions in the field. Although most of the full-text articles assessed passed the eligibility criteria, I excluded some articles because they were either based on secondary data and owned by external agencies or involved participants over 18 years. In addition, some studies that did not explicitly mention research participants and study areas in their abstracts were unintentionally considered but excluded from the full-texts appraisal. Some studies within early childhood education (ECD) and higher education were among those excluded from the appraisal.

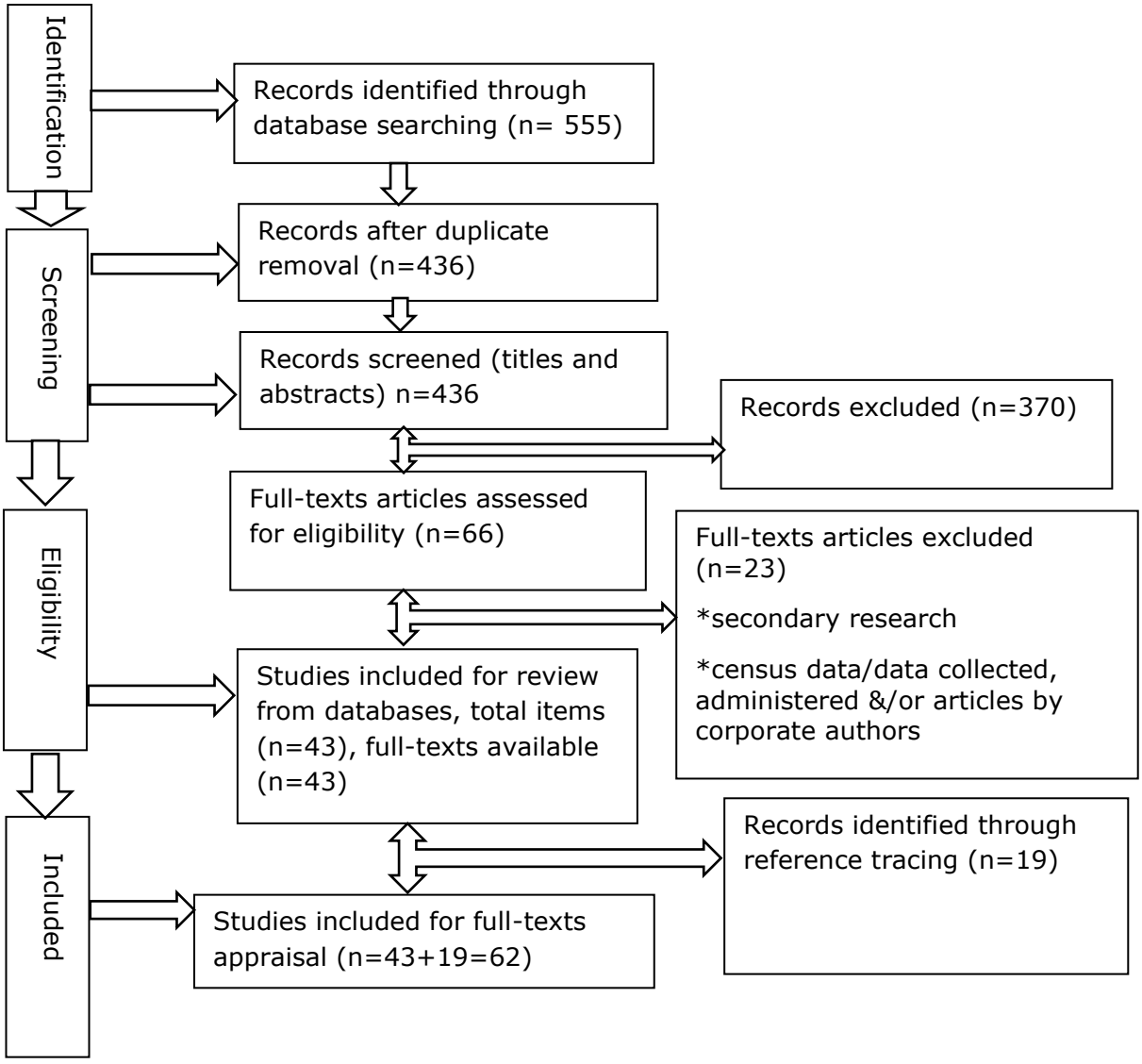

Figure 3.5: PRISMA-Flowchart demonstrating screening and quality appraisal process (adapted from Liberati et al., 2009).

4. Analysis and Synthesis I

This chapter provides perspectives into meta-data assembled from all the articles included and coded according to the respective variables assigned in the studies. This includes data such as the year of publication, country of research origin, research methodology, research settings and some crucial information related to participants, like gender and their placement in different Grades/Classes in schools. Importantly, these data are used to provide a macro perspective into studies while presenting background information of the original research using tools of descriptive statistics.

During the preliminary stages of analysis using the NVivo software, I gathered the meta-data which build a solid background for the review and might orient the readers for further analysis and synthesis. Moreover, the software helped the exploration of multiple variables and visualization in graphics tools convenient to analyse and understand in the context of the subsequent interpretations and discussions. Thus, attempts have been made to provide a bird's eye view using visual representations while setting the transparent scene for the knowledge claims to be presented and discussed in the following chapters. In other words, the analysis of meta-data should orient the readers about the background and sources of knowledge claims I strive to build in the subsequent chapters. This means I aim to provide readers with the necessary information required to comprehend core findings which answer the review questions in the following chapter. Below is a complete overview of the articles included in the review. The articles are presented in alphabetical order and are accompanied by key information like author, year of publication, host country, research focus and the number of participants involved in the research.

An overview of studies included in the analysis

Author & Year	Country	Title	Focus	Number of participants
Ale, Loh & Chib, 2017	India	Contextualized-OLPC education project in rural India: measuring learning impact and mediation of computer self-efficacy.	Assess the impacts of technology introduction in primary schools	205
Aliasgari, Riahinia & Mojdehavar, 2010	Iran	Computer-assisted instruction and student attitudes towards learning mathematics	Study the effects of computer-assisted instruction in learning level in grade two	50
Amiama-Espaillat & Mayor-Ruiz, 2017	Dominican Republic	Digital Reading and Reading Competence: The Influence in the Z Generation from the Dominican Republic	Evaluate the internet use and impacts in adolescents in grade ten in public and private schools	382

Angrist & Lavy, 2002	Israel	New evidence on classroom computers and pupil learning	Assess the impacts of computerisation on the instructional use and pupil achievement	10,941
Bacelo, Roldan-Alvarez & Martin, 2020	Spain	Turns vs consensus: learning mathematics in multi-touch surfaces	Explore the mathematics learning experiences using digital tool	77
Bai et al., 2016	China	The impacts of integrating ICT with teaching: evidence from a randomized controlled trial in rural schools in China	Measure the iimacts of ICT integration in teaching and learning English	6,304
Ball et al., 2019	USA	The emotional costs of computers: an expentency value theory analysis of predominantly low-socioeconomic status minority students´STEM attitudes	Examine the STEM attitudes of low-socioeconomic minority children	1,045
Burusic, Simunovic & Sakic, 2021	Croatia	Technology-based activities at home and STEM school achievement: the moderating effects of student gender and parental education	Explore the relationship between students´technology use and STEM achievement in grades five and six	1,205
Cadamuro et al., 2020	Italy	Making the school smart: The interactive whilteboard against disparities in children stemming from low metacognitive skills	Evaluate the impacts of IWB on knowledge performance on grades four and five students	184
Camerini & Schulz, 2018	Switzerland	The social inequalities of internet access, its use, and the impact on children's academic performance: evidence from a longitudinal study in Switzerland	Explore the differences in internet access and use among grade four learners	843
Carr, 2012	USA	Does Math Achievement h´APP´en when iPads and Game-Based Learning and Incorporated into Fifth-Grade Mathematics Instruction?	Examine the effects of 1:1 iPad use on maths achievement	104
Chao, Chen & Chuang, 2014	Taiwan	Exploring students´learning attitudes and achievement in flipped learning supported computer aided design curriculum: A study in high school engineering education	Explore the benefits of flipped learning among female learners in grade 11	91

Crook, Sharma & Wilson, 2015	Australia	An Evaluation of the Impact of 1:1 Laptops on Students Attainment in Senior High School Sciences	Evaluate the roles of 1:1 laptops in science performance	967
Dangwal, Sharma & Hazarika, 2014	India	Hole-in-the-Wall learning stations and academic performance among rural children in India	Explore the maths and English impacts of self-regulated digital learning on grades 6 & 7 students	135
Dhir, Chen & Nieminen, 2016	India	The effects of demographics, technology accessibility, and willingness to communicate in predicting internet gratifications and heavy internet use among adolescents	Find out relationships among internet gratification, users´ characteristics and usage	1,914
Ellison & Drew, 2020	UK	Using digital sandbox gaming to improve creativity within boys´writing	Assess the influence of Minecraft use in promoting writing performance of boys	8
Fairlie, 2015	USA	Do Boys and Girls Use Computers Differently, and does It Contribute to Why Boys do Worse in Schhol Than Girls?	Examine time invested on computer use and academic achievement	1,123
Ferrer, Belvis & Pamies, 2011	Spain	Tablet PCs, academic results and educational inequalities	Evaluate the impacts of digital whiteboard implementation in public schools	6342
Genlott & Gronlund, 2016	Sweden	Closing the gaps -Improving literacy and mathematics by ict-enhanced collaboration	Compare the results from traditional and ICT integrated classrooms in grade three	502
Gulek & Demirtas, 2005	USA	Learning with technology: The impacts of laptop use on student achievement	Assess the impacts of school-based laptop usage on middle school performance	259
Gunduz, 2010	Turkey	Digital Divide in Turkish Primary Schools: Sakarya Sample	Assess the digital divide conditions and their impacts in elementary school grades	420
Hansen et al., 2012	Ethiopia	Laptop usage affects abstract reasoning of children in the developing world	Assess the impacts of low-cost laptops in middle school children	413
Heemskerk et al., 2009	Netherlands	Gender inclusiveness in educational technology and learning eperiences of girls and boys	Evaluate the inclusiveness of educational software and learning experiences of boys and girls in grade nine	81

Huang, Liang & Chiu, 2013	Taiwan	Gender differences in the reading of E-books: Inventigating children's attitudes, reading behaviors and outcomes	Explore the gender differences in reading of e-books	166
Hunley et al., 2005	USA	Adolescent Computer use and academic achievement	Inventigate the grade ten students´computer use and its impacts in GPA	101
Jackson et al., 2006	USA	Does Home Internet Use Influence the Academic Performance of Low-Income Children?	Examine the antecedents and consequences of home internet use in African-American children	140
Jackson et al., 2007	USA	What children do on the internet: domains visited and their relationship to socio-demographic characteristics and academic performance	Examine the antecedents and consequences of home internet use in African-American children	140
Jackson et al., 2008	USA	Race, gender, and information technology use: The new digital divide	Explore the race and gender differences in ICT use and academic performance	515
Ke & Grabowski, 2007	USA	Gameplaying for maths learning: cooperative or not?	Measure effects of gameplaying on fifth grades' maths performance and attitudes	125
Koivusilta, Lintonen & Rimpela, 2007	Finland	Orientations in adolescent use of information and communication technology: A digital divide by sociodemographic background, educational career, and health	Explore the adolescents' use of ICT	7292
Lei & Zhao, 2007	USA	Technology uses and student achievement: A longitudinal study	Identify what and how technology affects students' GPA	177
Lei & Zhou, 2012	China	Digital Divide: How Do Home Internet Access and Parental Support Affect Student Outcomes?	Examine home intenet access, parental support and student outcomes	1,576
Lei, 2010	USA	Quantity versus quality: A new approach to examine the relationship between technology use and student outcomes	Explore the association between technology use and student outcomes in grades seven and eight	133
Li & Chu, 2021	Hong Kong	Exploring the effects of gamification pedagogy on children's reading: A mixed-method study on academic	Examine the effects of an online gamified reading platform on grade four students	84

		performance, reading-related mentality and behaviors, and sustainability		
Li & Ranieri, 2012	China	Educational and social correlates of the digital divide for rural and urban children: A study on primary school students in a provincial city of China	Explore the digital divide issues among from an educational and social perspective	658
Malamud et al., 2019	Peru	Do children benefit from internet access? Experimental evidence from Peru	Measure the impacts of home internet access on learning outcomes in children in grades 3-5	2,126
Malhi, Bharti & Sidhu, 2016	India	Use of electronic media and its relationship with academic achievement among school going adolescents	Examine the patterns of media use and academic achievement in teens	362
Master et al., 2017	USA	Programming experience promotes higher STEM motivation among first-grade girls	Examine the STEM-related stereotypes and impacts of programming intervention on young learners	96
Meza-Cordero, 2017	Costa Rica	Learn to play and play to learn: Evaluation of the one laptop per child program in Costa Rica	Evaluate the effects of OLPC program on learning achievement	3300
MoBle et al., 2010	Germany	Media use and school achievement -boys at risk?	Explore the relationships between the time spent with different media and adolescents' academic performance	6,686
Mora, Escardibul & Pietro, 2018	Catalonia	Computers and students´achievement: An analysis of the One Laptop per Child in Catalonia	Measure the impact of a OLPC program in grade ten	175,493
Palomares-Ruiz et al., 2020	Spain	Influence of ICTs on math teaching-learning processes and their connection to the digital gender gap	Show the relationships between ICT, gender and maths performance	123
Park, Khan & Petrina, 2009	Korea	ICT in Science Education: A quasi-experimental study of achievement, attitudes towards science, and career aspirations of Korean middle school students	Examine the contributions of computer-assisted instruction in science classrooms	234
Poulain et al., 2018	Germany	Cross-sectional and longitudinal associations of screen time and physical	Assess the relationships of media consumption and school achievement	1,362

		activity with school performance at different types of secondary school		
Putjorn, Ang & Farzin, 2014	Thailand	Understanding tablet computer usage among primary school students in underdeveloped areas: students´technology experience, learning styles and attitudes	Assess the impacts of OLPC on academic outcomes in grade two	213
Robinson, Wiborg & Schulz, 2018	USA	Interlocking inequalities: Digital stratification meets academic stratification	Measure the effects of digital inequality on academic performance measured in GPA	972
Roesch, et al., 2016	Germany	Training arithmetic and orthography on web-based and socially-interactive learning platform	Explore the learning impacts of web-supported interactive platforms	400
Sharif et al., 2010	USA	Effect of Visual Media Use on School Performance: A Prospective Study	Identify mechanisms for the impact of visual media use on adolescents' school performance	6,486
Shin et al., 2012	USA	Effects of game technology on elementary student learning in mathematics	Assess the effects of game technology in math performance on grade two learners	41
Starkey & Zhong, 2018	New Zealand	The effect of netbook ownership on children's academic achievement in mathematics, reading, and writing	Measure the impacts of netbook use in schools on children's learning	641
Sung, Chang & Huang, 2007	Taiwan	Improving children's reading comprehension and use of strategies through computer-based strategy training	Assess the influence of computer-assisted instruction on reading in grade six students	130
Sung, Shih & Chang, 2015	Taiwan	The effects of 3D-representation instruction on composite-solid surface-area learning for elementary school students	Assess the effects of instruction using digital tools on learning math in grade five	111
Swinnen et al., 2013	China	Can One-to-One Computing Narrow the Digital Divide and the Educational Gap in China? The Case of Beijing Migrant Schools	Assess the effectiveness of OLPC program in grade three	300
Tadayonifar & Entezari, 2020	Iran	Does flipped learning afftect language skills and learning styles differently?	Explore the relationships between flipped learning,	40

			language skills and learning styles	
Wang, 2016	Taiwan	Could a mobile-assisted learning system support flipped classrooms for classical Chinese learning?	To develop a mobile-assisted flipped learning and to invenstigate learning impacts in teens	56
Wolsey & Grisham, 2007	USA	Adolescents and the New Literacies: Writing Engegement	Investigate the usefulness of technology use and teaching in grade eight	*
Wong, 2015	China	Digital Divide Challenges of Children in Low-Income Families: The Case of Shanghai	Assess the relationships between internet access and academic and psychosocial attributes in 9-17 years old children	1,595
Wright, 2017	USA	Cyberstalking Victimization, Depression, and Academic Performance: The Role of Perceived Social Support from Parents	Explore the impacts of cyberstalking, social support and academic performance in grade 12	413
Yong, 2017	Malaysia	Digital Native Students: Gender Differences in Mathematics and Gaming	Explore gender differences in technology use and its impacts in academic performance	196
Yusuf & Afolabi, 2010	Nigeria	Effects of computer assisted instruction (CAI) on secondary school students´ performance in Biology	Explore the relationships between CAI, gender and biology performance	120
Zhang, 2015	USA	Understanding the relationships between interest in online math games and academic performance	Explore the relationships between interest, volumes of game search and math and reading performance in grade four	*
Zhang, 2016	USA	Dicsovering the unequal interest in popular online educational games and its implications: A case study	Examine the relationship between interest in a popular children-oriented educational gaming site, academic performance and socio-demographic factors	*

Table 4.1: An overview of articles included in the review

*These articles employ data from web-search and do not reveal the exact number of participants involved in the research.

4.1 Study Distribution by Year of Publication

The bar graph (Figure 8) presents an overview of the research published in the study years 2000-2020. The publication trends show very limited studies in the first

decade of digital divide research since its inception in the mid-1990s. The last decade, however, witnessed significant progress as every year documents some contributions in the field. Except for the year 2019 which documented only two research articles, the publication trends in the last half of the decade seem noteworthy for the field. Three research articles every year during the study period show that children's diverse digital experiences are of scholarly concern. This is reflected in an uninterrupted publication since 2005 when the effects of digital inequalities emerged as interdisciplinary debates.

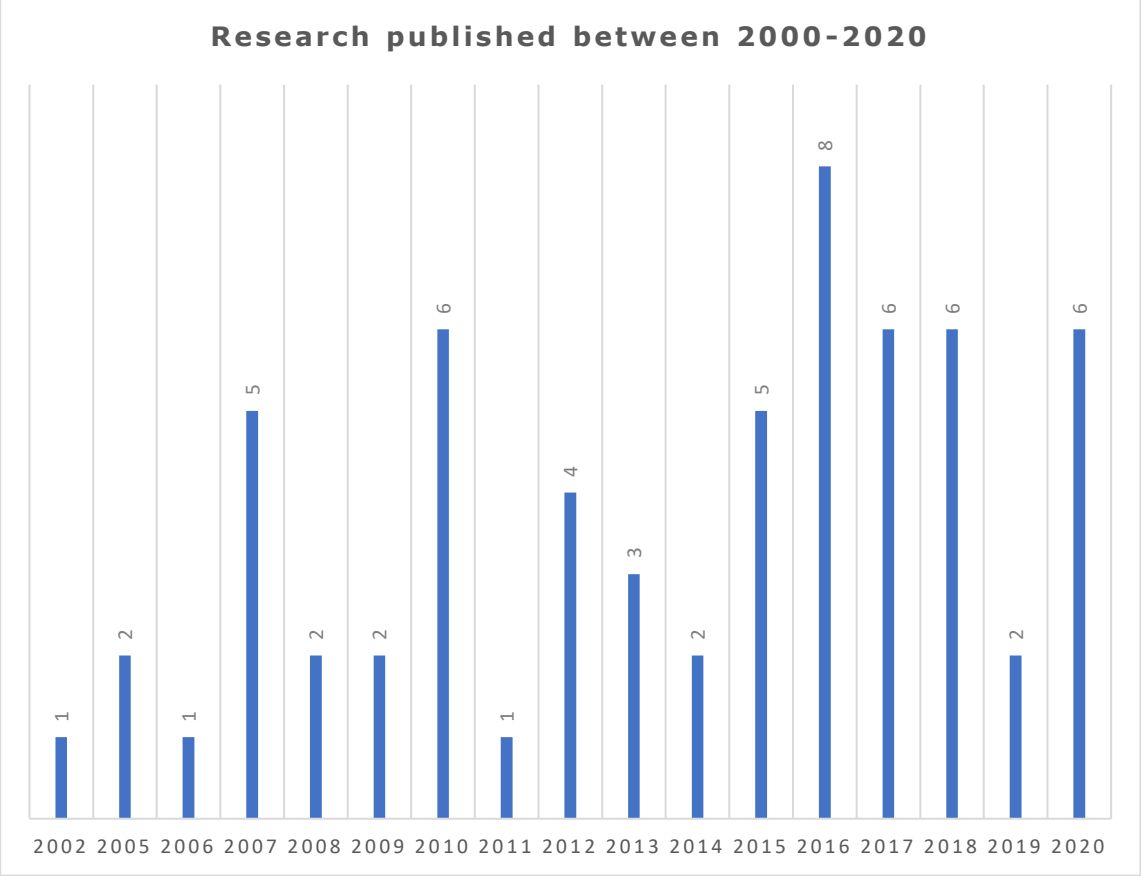

Figure 4.1: Study distribution by the publication year of original articles

4.2 Study Distribution by Countries

As mentioned in the studies under review, the USA hosted a noticeably higher number of research (n=19) which is approximately 31% of the sum of the studies. The two neighbouring countries Taiwan and China provided sites for studies (n=5 each) which cover more than 16% of the sum followed by Spain and India which carried out n=4 studies in each. Similarly, Germany and Iran are another two host countries with 4.84% and 3.23% research while the rest of the countries in the statistics have an equal share of 1.65% providing space for n=1 study each.

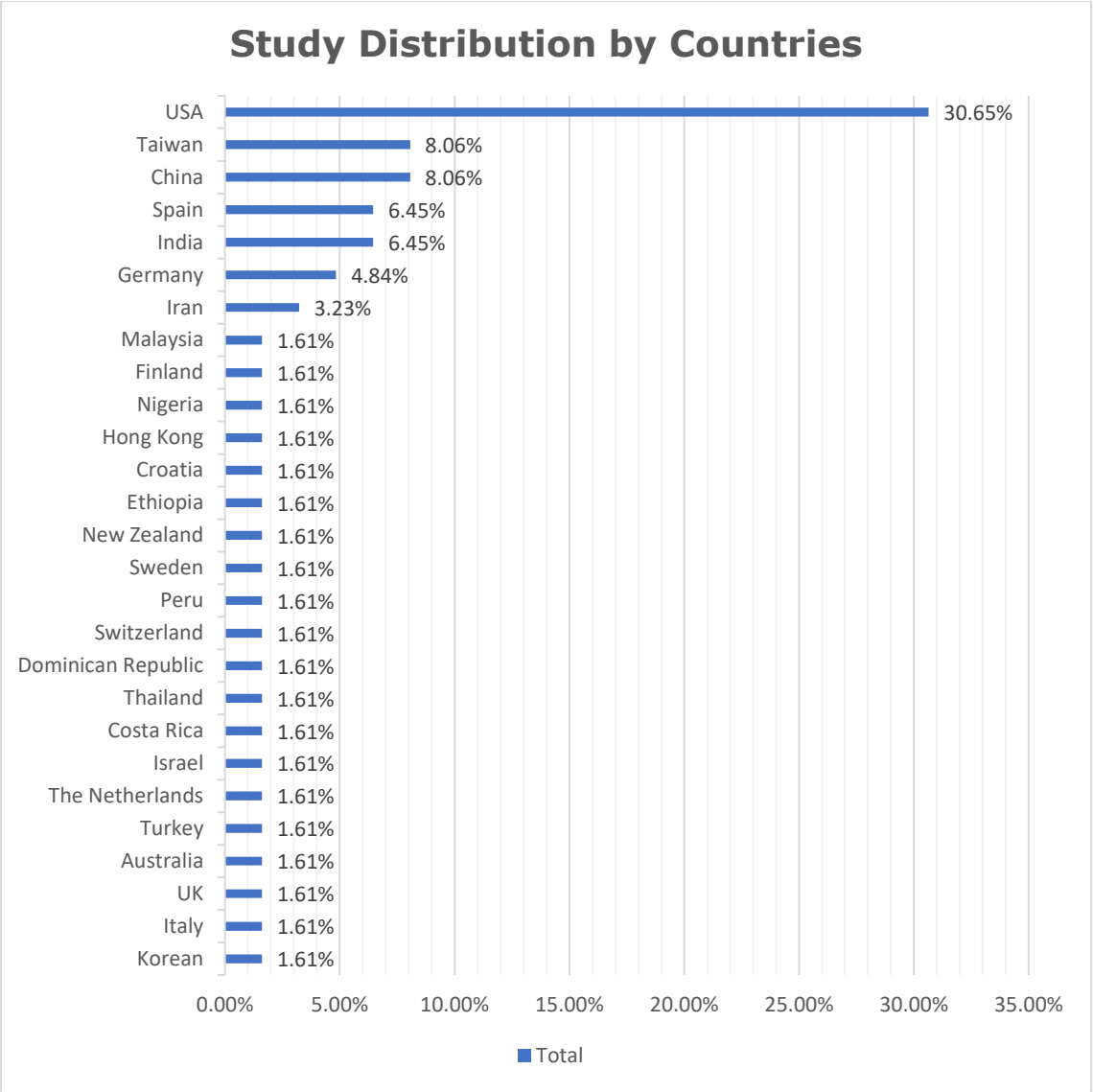

Figure 4.2: Study distribution by countries of research origin

Below is a geographical map marked in colours that represent the frequency of studies in respective countries. The visual data shows that the Northern American research phenomenon dominates the body of knowledge while it is scarce in Europe, Latin America, the Caribbean, Africa, and Australia. This clearly indicates that the issue of digital divides in children's formal learning fails to attract scholarly attention even in the Global North. While children's digital behaviours attract ever-increasing attention around the globe, this pressing issue remains nearly unexplored in many contexts given that there is a growing tendency to recognize children as co-researchers/researchers. This is a serious concern also for the current review because it presents a solid ground to question the generalizability of the new knowledge I strive to contribute to the field. Nevertheless, the meta-data shows that studies of the current review represent different regions, and not the least, all continents except Antarctica.

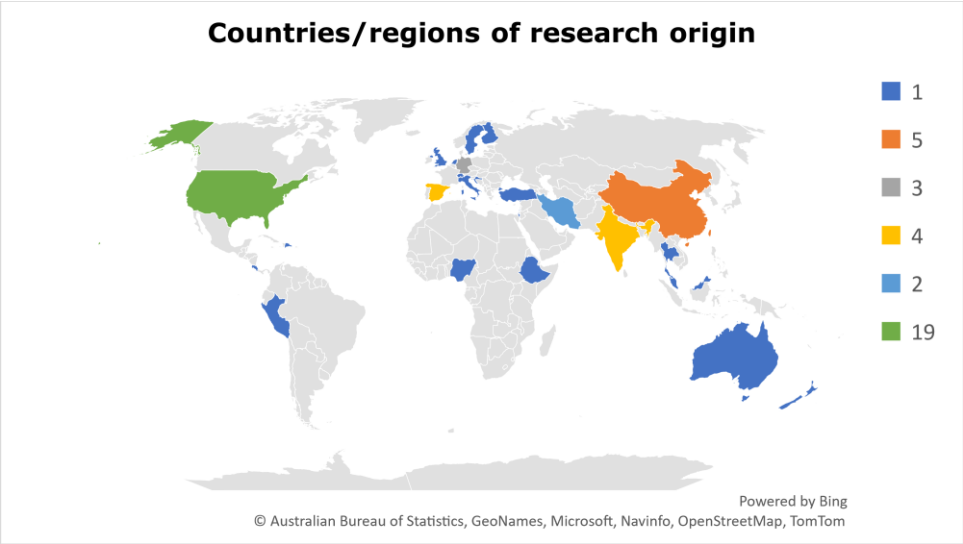

Figure 4.3: Study distribution by countries and regions

4.3 Study Distribution by Participants

While studies were exclusively distributed across primary and high school, I categorize them into four different groups based on the educational structure and organization of the USA since the country hosts a noticeably higher number of research (see the map above). Thus, readers need to bear in mind that studies assigned to grades 1-4 fall somewhere between them, but they do not necessarily involve learners from all grades. Similar is the case with other categories including mixed grades. Study distribution by grades shows the highest number of studies (n=21) concentrated between grades 5-8, also referred to as middle school or lower secondary school, followed by (n=17) studies representing mixed grades. This means those studies involved diverse participants from primary, lower secondary and high school. Similarly, the quantity of studies representing grades 1-4 and grades 9-12 is equally suggesting equivalent research interests in elementary and secondary school.

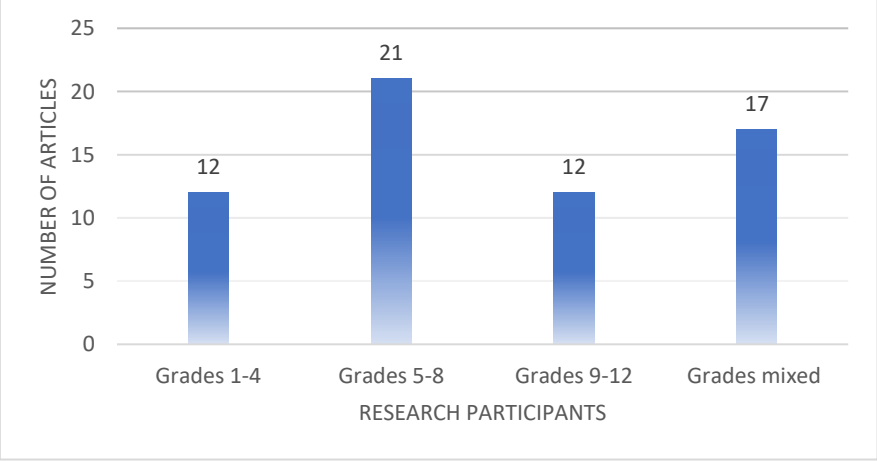

Figure 4.4: Study distribution by research participants

Likewise, there are different practices concerning school enrolment and upgrading given the variation in educational structures and choices in different countries. Grade retention and promotion are yet another practice in a school system which may lead to the false generalization that 16 years old children attend grade ten. This is why I have chosen to categorize pupils according to the grade they attended when the research was carried out. This suggests no direct reasoning between the age and grade of the pupils. Nevertheless, these two variables, of course, are useful to draw inferences from each other.

4.4 Study Distribution by Gender

The diagram below shows that a great deal of research involved both boys and girls. This indicates the gender variable is a significant attribute emphasized in several studies. Similarly, two of the studies have kept gender factor covert. Only boys were participants in a single study while only girls were involved in two of them. This suggests that gender is seen as interesting from a comparative perspective.

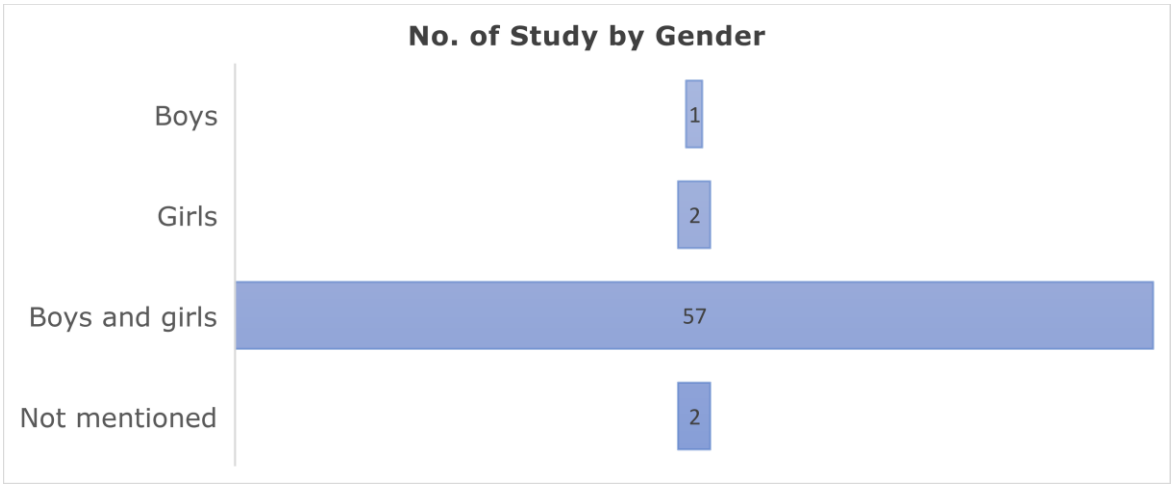

Figure 4.5 Study distribution by gender of the participants

4.5 Study Distribution by Setting

While four of the studies used online platforms, and virtual modes to collect the data, a significant number of researchers visited the research settings, the schools. Since only a handful of the studies mentioned school geography and whether they were government funded, I preferred to categorize them simply under 'school'. Only seven of the included studies involved both home and school settings for collecting their data. The last five of them studied children in their home settings.

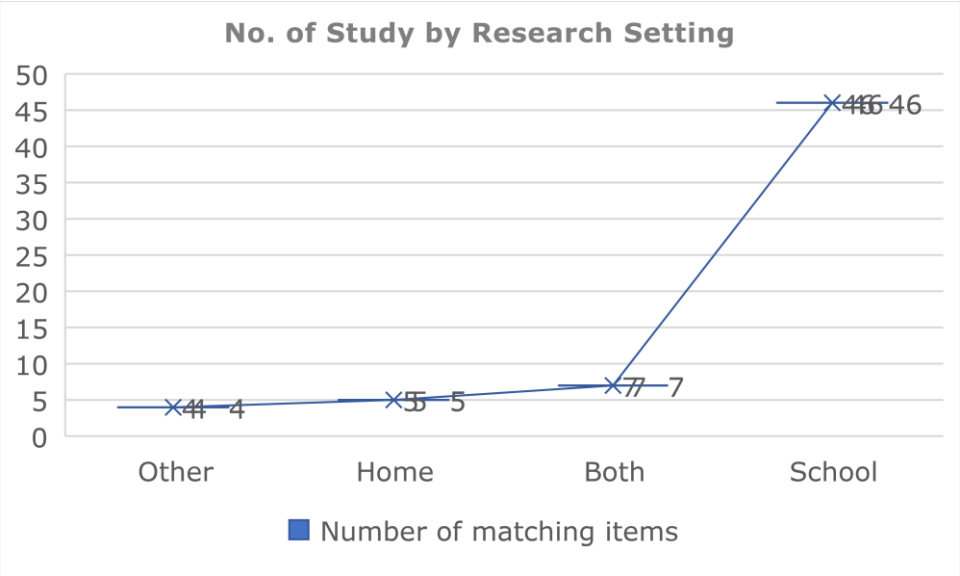

Figure 4.6: Study distribution by research setting

4.6 Study Distribution by Design

Study distribution by design presented in the table below shows that two-thirds of the studies had a quantitative design involving surveys and experimental designs. Besides, 11 studies employed quasi-experiment, six used mixed-method and three of them used data available on the internet and document analysis. To my surprise, only one of the studies in this review employed a pure qualitative design. These scenarios point towards the use of words/phrases during the database search which is also reflected in the research questions. Moreover, the words such as academic/learning/ educational achievement, learning gap, school performance/achievement and academic success used in the literature search practically generated references close to the effects/impacts of digital divides in learning. Besides, as mentioned in the review criteria, studies based on measurable outcomes of using or not using digital resources were preferred against studies which reported perceived outcomes/impacts. This has been significant for arriving at studies that employed respective designs.

This presents both opportunities and challenges for the current review. As it is a common scholarly practice, the studies under review collect/generate data from a large number of participants, which is considered an advantage because of the representativeness or generalizability of the new knowledge (Bernard, 2013; Lund, 2012; Thomann & Maggetti, 2020). In addition, complex designs (quantitative and mixed methods) are often claimed to generate robust findings that involve less or no researcher bias (Angelova et al., 2012; Caruth, 2013), often associated with qualitative designs. Moreover, the homogeneity between studies is an advantage for the reviewer to minimize bias (Newman & Gough, 2020). Contrary to this, the lack of representation of

qualitative studies results in the absence of in-depth and contextual knowledge likely to be generated using such designs (Thomann & Maggetti, 2020).

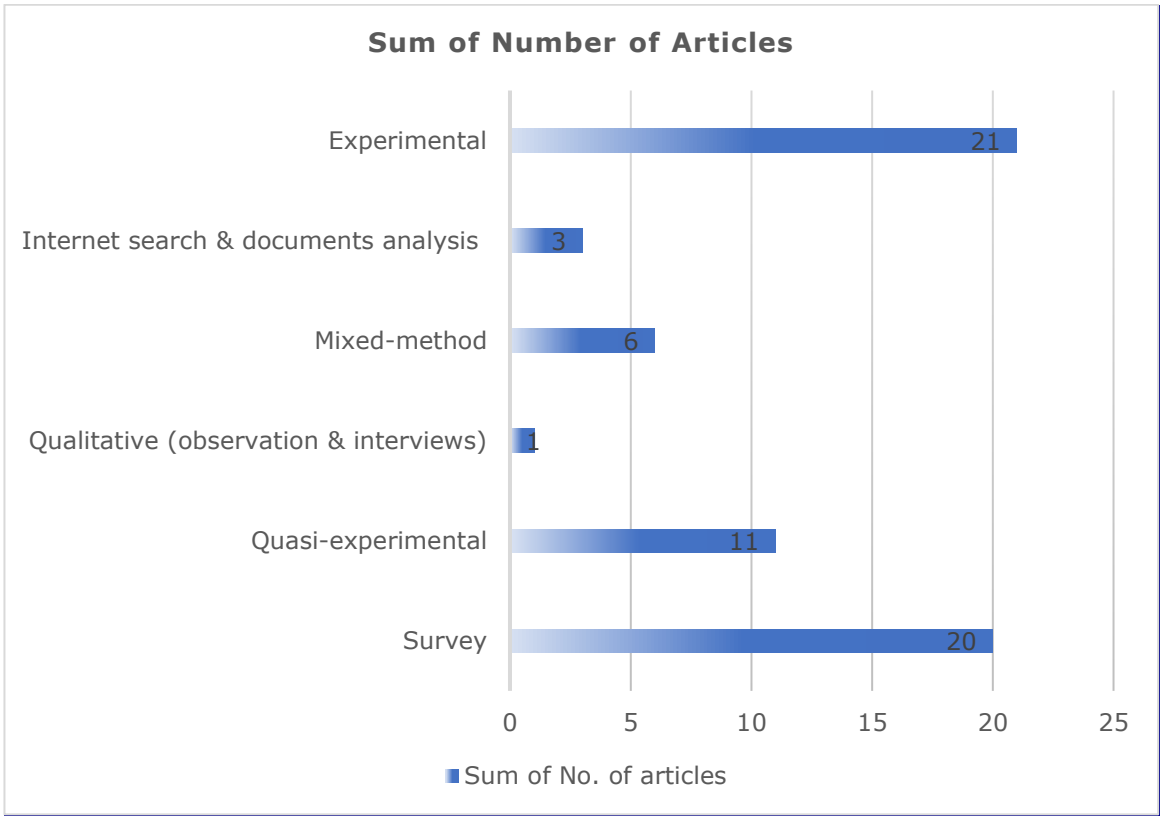

Figure 4.7: Study distribution by research design

The series of exercises in the course of the macro analysis provided meaningful opportunities to read the literature reiteratively. As a result, I started sensing both similar and diverse patterns which in later stages were assigned with different codes. For this purpose, I used NVivo which facilitated coding and re-examining them in a recurrent manner. This exercise has been helpful to identify both supporting and conflicting accounts in the evidence while developing logical arguments required to satisfy the research questions (Efron & Ravid, 2019). Moreover, the pursuit in both the macro and micro analysis has been to provide logical explanations to develop a coherent narrative as the new knowledge. Although methodological homogeneity is revealed from the original research, there is variation in the manner findings are reported. This heterogeneity in the evidence required a narrative-based approach to evidence synthesis (Pope et al., 2007). This is practised in both macro and micro analysis while benefitting from some tools of descriptive statistics (i.e., charts and figures). Below I will use the findings to answer the research questions.

5. Analysis and Synthesis II

The aim of this chapter is to provide a narrative synthesis of the evidence reviewed. Using this approach, I have analysed data and generated meanings from an array of research informed by different theoretical and methodological traditions (Goagoses & Koglin, 2020). Following the logic of narrative synthesis, I present answers to the review questions in texts and stories while providing coherent narratives for different themes generated from recurrent coding processes (see Dixon-Woods et al., 2005). Those themes are organized under each of the three research questions: RQ1: What factors influence children's digital technology use and academic performance? RQ2: Which academic and non-academic learning areas are influenced positively and/or negatively by children's digital technology use? And RQ3: Which group of children acquire academic benefits from digital exposure? Why? Moreover, the themes and answers to the research questions follow the central arguments presented in the original research.

RQ1. What factors influence children's digital technology use and academic performance?

A clear majority of research articles (40/62) discuss a range of conditions which influence children's academic performance in schools. Those conditions are wide-ranging encompassing individual attributes to external and environmental factors which constitute social, cultural, and economic assets of the family and even schools. Those factors are presented with narratives and analysed in light of theoretical and conceptual notions described earlier.

5.1 Socio-economic Status and Digital Access

The notion of the first level digital divide i.e., availability of (home) computers and the internet is studied as an important factor that influences children's academic performance. The impacts of such availability are studied also relating to some global efforts in school education such as OLPC and World Computer Exchange. A study of OLPC intervention shows that grade three learners in Beijing migrant schools improved their self-esteem, computer skills and math results (Mo et al., 2013). The same study mentions that "substituted television watching time with time on the computer could have improved the students' academic results after the programme" (Mo et al., 2013, p. 22). Similarly, home internet access is also found to be beneficial in reading performance among low-achieving children and adolescents, because of increased online reading opportunities not available to their digitally deprived peers (Jackson et al., 2006). The findings of these studies are consistent with empirical evidence from the early years of digital divide research, for example, Rocheleau (1995) and Judge (2005) to relatively new evidence such as Dangwal et al. (2014) and Ogundari (2023). The study by Dangwal et al. (2014) finds that children having some access to digital learning environments such

as the Hole-in-the-Wall project in rural India improved their test scores in English and mathematics despite ethnic, geographic, cultural, and religious diversity among them. In addition, Ogundari (2023) observe that access to digital technology was significant to extend learning hours across diverse groups of children in the USA.

Beyond the digital access and home internet availability to children, the socio-economic status of the family as well as schools influences how digital resources are translated into academic gains. This indicates that children belonging to higher SES utilize computers and the internet for more educational use than entertainment and communication purposes, which highlights inequalities in computer use (Camerini et al., 2018). Gunduz (2010) finds positive learning outcomes from the use of computers among socio-economically advantaged children. Similarly, Camerini et al. (2018) also document similar findings in a study of Italian-speaking children in Switzerland who demonstrated non-educational use of new media as a result of disadvantaged SES, reproducing pre-existing social inequalities.

Different scholars suggest that the time invested by children in the educational use of digital media is positively related to academic gains, while entertainment use is negatively associated with it (Dhir et al., 2016; Fairlie, 2016; Xiao & Sun, 2022). A recent study using PISA data documents findings from a sample of 4,838 American high school learners that entertainment use of ICT has negative outcomes in all aspects of academic performance (Xiao & Sun, 2022). This is parallel with the findings of PISA results in other contexts as well (Bulut & Cutumisu, 2017; Park & Weng, 2020; Srijamdee & Pholphirul, 2020). These insights are in line with additional evidence concerning the non-academic use of ICT and learners' performance in different aspects of science, technology, engineering, and mathematics, popularly referred to as STEM fields (Burusic et al., 2021). This indicates that poor academic performance is closely related to the non-educational use of digital tools and resources.

5.2 Socio-demography (Race, Gender and Age)

Studies that considered race and/or gender as variables for inquiry report mixed findings from digitally supported learning contexts. Jackson et al. (2008) find both race and gender differences in the intensity and the nature of children's ICT use mediated by parents' socio-demographic characteristics, all of which help explain why some children do worse academically. The only article that explores race as a factor, concludes that African American males (average 12 years) demonstrated scarce use of computers and the internet while they used video games the most, which negatively influenced academic performance (Jackson et al., 2008). Recent research shows inequalities in access and use of different digital technology across races in the USA (Ogundari, 2023). This study mentions that White and Asian students are at the forefront concerning the educational use of the available digital platforms followed by Hispanic, Black and other

races. Even after controlling family SES, girls are observed to effectively use digital content as resources for learning compared to boys, which influenced their academic achievement in STEM domains differently (Burusic et al., 2021). Similarly, gender differences in digital reading are also reported in favour of girls in a performance study of e-book reading while "boys experienced distraction due to their greater technology acceptance" (Huang et al., 2013, p. 106). Other studies, however, reveal that "boys enforce a sense of power and control over girls in the computer classroom" (Ale et al., 2017, p. 772), and that girls lack enthusiasm for learning when provided less inclusive learning platforms mediated by digital technologies (Heemskerk et al., 2009). On the contrary, girls' motivation and learning outcomes improved when teachers used interesting texts, visual materials, and cooperative approaches to foster new learning. Besides, STEM-related stereotypes reinforced by parents, teachers and fellow learners are found to undermine female learners' potential in these domains, which negatively affects girls' self-confidence and outcomes in the learning (Bhanot & Jovanovic, 2009; Bleeker & Jacobs, 2004; Tiedemann, 2002). However, it is also reported that boys are more prone to violent media content use, which is associated with school-related achievement problems (Mössle et al., 2010), along with anxiety, depression and suicidal behaviours (Stoilova et al., 2021). These show that digital use cannot be equated with learning and skills development, particularly when it is not directed to educational use.

This suggests that boys and girls respond to learning platforms differently, and how teachers operationalize the formal curriculum, learning materials or digital resources affects learning outcomes. Some critical reflections on contents (i.e., learner responsive) interface (i.e., audio-visual aspects) and instruction (strategies for input and feedback) seem valuable to any effort towards making the learning environment inclusive[5] to all the learners.

Though there are only two studies that focus age factor, they provide significant insights that younger learners lack the necessary skills to demonstrate independent use of diverse applications compared to adolescents, (in grades 6 and 7) who can extend learning with technology beyond the classroom (Angrist & Lavy, 2002; Hansen et al., 2012). A national survey among teenagers (n=789) in the UK pointed out similar findings, suggesting positive associations between age, digital skills and opportunities they experienced (Livingstone & Helsper, 2010). The relationships between digital skills and various outcomes are explored in different studies (Blank & Lutz, 2018; Stoilova et al., 2021; Van Deursen & Helsper, 2015). When observed only the young children, high-performing learners utilize digital technology for educational purposes more compared to their low-performing counterparts (Judge, 2005). These pieces of evidence show that socio-economic and socio-demographic factors significantly influence digital participation,

[5] For index of inclusive learning design, see Heemskerk et al., 2009.

and skills, which further help to explain the quality of digital use and outcomes across diverse groups of children and adolescents. As discussed earlier, users' attitudes, motivation and experiences with digital platforms also interact with the nature of digital use and academic performance suggesting diverse impacts on boys and girls in different digital platforms (Heemskerk et al., 2009).

5.3 Social Support (Guidance, Monitoring and Supervision)

The patterns in data from several studies underscore that the parental role is significant for children's learning experiences in digitally mediated environments. A plethora of knowledge reveals the importance of effective parental support, guidance, supervision and monitoring in children's transactions with digital platforms and resources (Hollingworth et al., 2011; Lei & Zhou, 2012; Malamud et al., 2019; Robinson et al., 2018; Vigdor et al., 2014; Wright, 2018). Moreover, a longitudinal study of adolescents (10-14 years) shows that the mother's role is critical in guiding and shaping educationally beneficial media behaviours (Sharif et al., 2010). The same study also suggests that maternal guidance in visual media use helped to decrease school-related and disciplinary problems (Sharif et al., 2010). Some scholars observe that restrictive mediation of online behaviours is particularly helpful to children with low self-control (Lee, 2013; Lei & Zhou, 2012). However, this mediation depends on the internet skills and parents' knowledge influenced by their social-economic backgrounds (Lee, 2013). In other words, social inequalities affect the parent's capacity to provide children with adequate support and guidance on digital skills which impacts how children use and experience different digital platforms and resources. However, Stoilova et al. (2021) argue, "Children who lack [such] social resources face a double disadvantage: they are more likely to experience online risks and are less likely to seek help" (p. 9).

5.4 Experience, Motivation, and Meta-cognitive Skills

Different user-related variables such as digital experience, knowledge and skills and motivation are frequently associated with children's academic attainment. Ale et al. (2017) identify that the problem is not exclusively of an inadequate provision of affordable technologies but of the lack of knowledge about the user-level psychological mechanisms that influence knowledge performance. Another study about the use of Interactive Whiteboards (IWB) in primary schools in Northern Italy supports the evidence affirming psychological processes such as metacognition to be a significant factor in knowledge performance (Cadamuro et al., 2020). The study reveals that boys and girls (grades four and five) in the experimental group displayed a higher performance compared to their peers in the control group. This study adds to the body of knowledge that IWB use in classrooms might reduce performance gaps between pupils.

Besides, information skills, knowledge of the foreign language and user's motivation in harnessing digital technologies hold explanatory power concerning why some Finnish adolescents do better at school than their counterparts (Koivusilta et al., 2007). The role of intrinsic motivation is highlighted also in reading research supported by a "gamified platform" that promoted "deep engagement and helped improve students' reading interest, motivation, habits and abilities, especially in second language reading" (Li & Chu, 2021, p. 174).

Similarly, technology experiences, collaborative learning style and anxiety affected academic performance. The latter factor affected learners in rural settings more despite higher learning competitiveness among the learners in grade two in Northern regions in Thailand (Pruet et al., 2016). Interestingly enough, children with learning disabilities experienced the highest positive impacts in the areas of English language arts, mathematics, and writing skills one year after intervening individual laptop programs in schools in California (Gulek & Demirtas, 2005).

5.5 Intervention Approach

Digital intervention programs incorporating socio-cultural perspectives into learning have yielded positive outcomes in different contexts. Crucially, opportunities for collaboration, social interaction, and timely feedback in formative assessment generated better literacy and mathematics outcomes irrespective of learners' gender variables in the "Write to Learn" program in grade three (Genlott & Grönlund, 2016). The study also discloses that learners' SES and teachers' roles were not significant. However, another study in public schools in central Pennsylvania mentions that while learners from different SES responded to collaborative game-playing approaches differently, socio-economically disadvantaged learners experienced more positive attitudes in math as the program result (Ke & Grabowski, 2007). These pieces of evidence show positive light in the sense that informed and inclusive designs can mitigate some of the consequences due to SES, abilities, public schools and traditional classrooms (Amiama-Espaillat & Mayor-Ruiz, 2017; Shin et al., 2012). Likewise, "personalized instruction together with monitoring and instant feedback as in CASTLE, allows personalized progress by placing a learner in an independent and threat-free situation" is found more effective in reading programmes (Sung et al., 2008, p. 1567). Scholarly observations also identify issues related to the programme contextualisation (Ale et al., 2017) and teacher efficiency (Bai et al., 2016) as significant factors that determine programme effectiveness.

RQ2. Which academic and non-academic learning areas are influenced positively and/or negatively by children's digital technology use?

I have tried to answer the research question from three different perspectives, i.e., positive impacts (both academic and non-academic outcomes), negative impacts and

no impacts/influence from the use of digital technology. These perspectives presented in different themes reveal that children's and adolescents' responses to digital technologies in formal learning are not identical, but widely diverse. This suggests the impacts of technological exposure on children are positive, neutral, and negative in different aspects and areas (directly) linked to their school performance. While presenting my themes, I have tried to incorporate those aspects as discussed in the evidence.

5.6 Positive Impacts

Of the 62 studies reviewed, slightly more than half of them (n=33) discuss findings in favor of techno-optimism suggesting positive impacts on children's and adolescents' developmental outcomes.

5.6.1 Academic Outcomes

STEM (Science, Technology, Engineering and Mathematics) domains are widely discussed in more than a dozen of research documenting positive impacts (Park et al., 2009). Within science, predominating areas of physics, chemistry and biology have witnessed measurable learning gains in Australian secondary schools equipped with 1:1 laptops (Crook et al., 2015). Additional evidence is available in favour of biology learning outcomes in the private secondary schools in Oyo State in Nigeria (Yusuf & Afolabi, 2010). The diverse range of advantages such as computer skills to math scores and students' improved self-esteem to more time spent in educational software are reported by Mo et al. (2013). Corresponding studies reveal impressive literacy and math performance among the Swedish Grade 3 learners exposed to the "Write to Learn" method supported by ICT in early grades (Genlott & Grönlund, 2016). Similarly, technical, and functional literacies are found to have improved via a contextualized implementation of OLPC in rural primary schools in India (Ale et al., 2017).
While game-based pedagogy is a more recent attraction in schools, Shin et al. (2012) find up to 16% higher learning gains in math just after a 5-weeks experimental intervention. Besides game contents, cooperative learning environments are claimed to yield better results in math both cognitively and affectively irrespective of learners' gender and learning differences (Ke & Grabowski, 2007). Programmes such as Dynamic Geometry and GeoGebra increase learners' efforts by creating space for more meaningful and relevant learning for them (Palomares-Ruiz et al., 2020). Interestingly, both previously mentioned shreds of evidence reveal better learning outcomes in female learners compared to their male counterparts who conventionally are claimed to outperform in STEM domains (Palomares-Ruiz et al., 2020; Shin et al., 2012). Likewise, research documents the effectiveness of a flipped-learning programme for Taiwanese

teens who underwent an eight-week intervention in the high school engineering learning (Chao et al., 2015).

Besides STEM advantages, the use of digital platforms and resources is claimed to increase performance in different areas of language skills. Iranian EFL (English as a Foreign Language) learners improved by up to 25% in speaking skills despite different learning needs and styles when flipped learning was implemented for a semester (Tadayonifar & Entezari, 2020). Similarly, gamified e-learning platform is observed to have positive outcomes in different in children's reading competence in primary schools in Hong Kong. The study reveals learners' curiosity, interest in reading, and mastery of reading-related activities improved by the end of the semester (Li & Chu, 2021). In the same amount of time, middle school learners in rural India are found to have achieved 19% more in English results compared to their peers in the control group who did not get exposure to the learning stations called Hole-in-the-Wall (Dangwal et al., 2014). Interestingly, those learning stations were not managed by educators but self-regulated by the learners who had the opportunity to explore the different digital resources of their interests.

Sung et al. (2008) show that children experience significant reading results within half of a semester when provided with effective computer-based strategy training. This challenges the evidence that suggests the duration of digital exposure influences children's academic performance (see Robinson et al., 2018). Those children who got the opportunity to use the internet for only a semester are observed with better reading achievements (Jackson et al., 2006). The study highlights the importance of the online reading opportunities available only to children who were connected to the internet. Nevertheless, Sung et al., (2008) emphasize the importance of effective instruction in digital application use and skills training, which children might benefit from for a long time.

Likewise, several studies explore improved writing achievements among children who did not have such an advantage before (Robinson et al., 2018). Besides improving students' attitudes about themselves as writers (Wolsey & Grisham, 2007), the use of digital applications (for example Minecraft) facilitates creativity and vocabulary choices in writing tasks (Ellison & Drew, 2020). Besides writing achievements, several psychological and academic benefits are documented among the learners who received both guidance and autonomy in using such applications (Baek et al., 2020; Callaghan, 2016; Fan et al., 2022).

Some studies explore the impacts of the internet on children's overall academic performance. While there were no significant learning gaps between the experimental and control groups, the former category of children receiving laptops demonstrated substantial achievement in different areas of academic learning (Gulek & Demirtas,

2005). Inequalities of the internet access and their impacts on digital skills and academic performance are observed frequently (Hurwitz & Schmitt, 2020; Li & Ranieri, 2013; Pagani et al., 2016; Robinson et al., 2018). This entails that the lack of access to digital technology creates adverse effects on digital self-efficacy and the quality of digital use, which seem to reproduce existing inequalities beyond digital divides (Stoilova et al., 2021). Furthermore, the (offline) inequality cycle seems to translate into digital inequalities creating diverse experiences and unequal terrain of opportunities also in the long run.

5.6.2 Non-academic Outcomes

Different studies explore positive relationships between digital technology use and various learning factors such as motivation, reasoning, study skills, and meta-cognitive and creative skills. Although the review aims to include studies reporting measurable learning gains, it is hard to ignore the available evidence that is highly significant in children's academic performance. Hansen et al. (2012) observe considerable differences in digital use and its impacts on reasoning skills and academic achievement in Ethiopian middle school children while Cadamuro et al. (2020) claim that learning digital skills generate multiple benefits such as improved meta-cognitive skills and academic achievement in Italian children at the same school level.

Similarly, two studies report improved motivation in learning using digital technologies (Wang, 2016; Wong et al., 2015). Wang (2016) observes that flipped learning system helped improve self-directed learning among Chinese high school learners while their peers in traditional classrooms did not show active participation in learning. More importantly, low-income, no-internet children are observed to have lower confidence in attaining the aspired qualification compared with middle or high-income and digitally connected children in Shanghai province in China (Wong et al., 2015). This shows that digitally disconnected children might experience severe consequences resulting from the lack of motivation to pursue higher education. This tendency is more prevalent among rural children than their urban counterparts who have narrow gaps in the digital use (Wong et al., 2015).

Several scholars argue that children learn and improve 21st-century skills from exposure to different digital platforms (Lewin & McNicol, 2015; Nouri et al., 2020; Van Laar et al., 2017). Free internet access alone has been observed to help children develop digital competence more than laptops without the internet (Malamud et al., 2019). In another context, such competence is found critical in knowledge exploration and academic achievement. Moreover, these scholars show positive associations between internet competence, internet exploratory behaviours and academic performance among children. Although the latter evidence is based on self-reported benefits, this documents

significant confidence of children as smart learners in digitally-mediated environments (Li & Ranieri, 2013). The quality of digital use and digital self-efficacy is linked to academic and developmental outcomes such as performance, self-esteem and positive attitude towards the school (Lei, 2010). This is in line with the finding that the "quality of technology use is more critical to students learning" (Lei & Zhao, 2007, p. 293), which suggests the importance of digital competence that involves not only operational skills but more critical skills involving research, creativity and collaboration.

5.7 Negative Impacts

Although children have been increasingly the target of digital supply at home and at schools, a great deal of evidence suggests the negative impacts of such intervention on academic performance. A longitudinal study of the OLPC programme implemented on secondary students in Catalonia observes consistently negative impacts on several of the school subjects like Catalan, Spanish, English and Mathematics (Mora et al., 2018). The academic performance record during the three years of intervention (2009-2012) and the next four consecutive years support the evidence that the academic performance of both boys and girls decreased, where the boys experienced higher learning loss than the girls (Mora et al., 2018).

Scholars explore negative associations of children's and adolescents' screen time with school achievement one year later, independent of socio-economic status and school type (Poulain et al., 2018). This is comparable with an earlier finding that children's search for popular online games was a negative predictor of reading and mathematics performance in the subsequent year (Zhang, 2016). Both shreds of evidence suggest the magnitude of screen time and interest in popular gaming sites cause poor academic performance among a diverse population of children. Digital gaming and mobile phone use are found more common among disadvantaged children who are more likely than their well-off peers to experience poor school achievement (Koivusilta et al., 2007). While it is not new that screen time seizes time for more meaningful educational activities (Poulain et al., 2018; Zhang, 2016), the use of visual media increases sensation-seeking behaviours in children, adversely affecting school performance (Sharif et al., 2010). A cross-sectional survey complemented by a longitudinal design reveals a similar correlation between electronic media use and school performance of 6,780 primary learners in German schools (Mössle et al., 2010). This study finds boys more at risk compared to girls in similar backgrounds. This seeks to suggest that only academically useful activities performed using digital tools and platforms create meaningful space for academic development (Robinson et al., 2018).

Sadly, while the popular use of technology is hardly rewarding for learning, the technology's potential to reward learning remains less explored also among middle school

children (Lei & Zhao, 2007). In other words, the more students use digital technology, the more they lose their GPA (Lei & Zhao, 2007). Recent findings reveal similar patterns in the evidence that entertainment use of digital technology predicts negative STEM achievements even after controlling gender and family-related factors (Burušić et al., 2021). Scholars further argue, "engaging in consumeristic and entertaining online activities does not only seem to impede learning benefits but also to decrease school grades as a form of learning outcomes" (Camerini et al., 2018, p. 2500). These scholarly observations show social, cultural, economic, and digital capitals are significant but more critical is the quality of digital use, which determines how children might do with their academic performance.

5.8 No Significant Outcomes

Unlike popular discourses, the empirical materials show that the impacts of the digital divide are not straightforward but complicated, making it difficult to anticipate outcomes. Several studies in the review did not show any significant improvements in the academic achievements of the children who were connected to digital learning platforms (Dhir et al., 2016; Hunley et al., 2005; Malamud et al., 2019; Meza-Cordero, 2017). This is true also in the context where close to all (except three out of 150) high school students reported having some digital competence (Hunley et al., 2005). Similar findings are revealed by a large study among US middle and high school children who were provided with home computers (Fairlie, 2016).

Similarly, an increase in home internet access underscores the null effects on the development of academic and cognitive skills for neither boys nor girls, highlighting the need for parental engagement in fostering academic learning using digital resources (Malamud et al., 2019). Similar evidence is revealed by Linda et al. (2006) concerning insignificant effects of internet use on mathematics test scores. Likewise, the provision of OLPC without guided use in the existing school curriculum did not provide learning benefits at least in the short term (Meza-Cordero, 2017). While it is often argued that quality over quantity of digital experience matters, using a variety of digital platforms failed to generate positive learning outcomes measured in GPA (see Lei, 2010). Though students' notebooks added a learning source, no significant difference is observed in the reading, writing or mathematics scores (Starkey & Zhong, 2019). This highlights the mediating roles played by different factors in which the study provides limited insights.

RQ 3: Which group of children acquire academic benefits from digital exposure? Why?

As children demonstrate diverse usages, skills, and motivations with digital technology, their dissimilar learning experiences show the *third digital divide*. The

empirical observations reveal complex relationships between the digital divide and children's offline outcomes.

5.9 Prospective Beneficiaries

One of the major aims of this study was to identify the beneficiaries of digital technology use. This means identifying the characteristics of learners benefitting from the network of (digital) resources is an important contribution towards bridging the educational gaps. Although only limited studies highlight such aspects, they provide valuable insights to inform policy and practice in the field.

Mo et al. (2013) observe that while the students in the intervention group improved in academic and non-academic outcomes (math, self-esteem, and digital skills), the underprivileged students gained more digital skills and improved self-esteem than their privileged peers. The intervention employed a well-designed digital learning package tailored to the school curriculum for slightly more than a semester in Beijing Migrant schools. In Swedish schools, results of the "Write to Learn" programme that employed ICT tools in learning show similar evidence as the target learners gained higher scores in literacy and mathematics, providing significantly better results for under-achievers in grade three (Genlott & Grönlund, 2016). The study further claims that social interaction and feedback are critical to better results rather than teachers´ skills and the socio-economic backgrounds of the learners. Elsewhere it is suggested that learning improves when learners get opportunities to decide the time and space but also the contents of learning materials (Wang, 2016). This indicates that opportunities to exercise learner agency/autonomy foster positive learning outcomes.

Similarly, low-performing female students are found to benefit more than others involved in learning mathematics using game technology (Shin et al., 2012). Significantly, the intervention allowed learners to create their own characters, which might have supported sustaining motivation in performing complex cognitive tasks. On the contrary, Park et al. (2009) find that boys more than girls benefitted from computer-assisted instruction (CAI) in learning science in schools in South Korea. Teachers' anecdotes show that girls were passively observant while boys participated in manipulating variables in the learning software (Park et al., 2009). Nevertheless, the evidence is consistent with other studies that observe low-performing learners compared to average and high-performing counterparts benefit more from technology intervention in schools (Genlott & Grönlund, 2016; Park et al., 2009; Sung et al., 2008). Sung et al. (2015) also document that the low-and-moderate ability students involved in the 3D-representation instruction exhibited greater improvements in learning mathematics. These scholars observe that the ICT-supported instruction helped to make abstract

concepts tangible, which complemented with individualized feedback increased learners' efficiency.

In addition, students with low reading ability had more to gain from the computer-assisted strategy teaching and learning (CASTL) programme implemented to support text comprehension for all ability learners in middle schools in Taiwan (Sung et al., 2008). The use of multiple strategies combined with individualized instruction might have generated better results for academically disadvantaged learners (Sung et al., 2008). This is true also in the case of interactive whiteboards (IWB) used in primary classrooms in Northern Italy that enhanced learning outcomes only among the students with low metacognitive skills (Cadamuro et al., 2020). The use of audio-visual tools available with IWB-supported instruction helped struggling learners better understand abstract concepts, which helped to reduce learning gaps (Cadamuro et al., 2020). The scholars further argue, "the IWB mitigates the detrimental effects of low metacognitive skills on learning and allows a similar performance of participants regardless of their individual level of metacognitive competencies" (Cadamuro et al., 2020, p. 38). Several studies in the review support the knowledge that children with learning difficulties benefit more from the educational use of digital tools and resources which appears to help minimize inequalities in academic performance (Ferrer et al., 2011; Linda et al., 2007; Pruet et al., 2016; Sung et al., 2015).

Furthermore, ICT intervention integrated with a cooperative learning approach is found to be critical towards helping low-performing children in different contexts. (Li & Chu, 2021) reveal the sustainable impacts of a gamified e-learning platform, which provided learners with the opportunity to engage in social interaction resulting in a sense of belonging and recognition. Besides, ICT integrated with a cooperative learning approach is suggested to encourage deeper exploration and dialogical interactions helping pupils articulate their thinking and reflect on their learning (Cadamuro et al., 2020). While learners collaborate as a team, they enrich each other with positive discussions that improve learning motivation and argumentative capacity (Bacelo et al., 2020). This suggests that ICT helps to enhance the agency of low-performing children, who are considered to have higher initial anxiety (Pruet et al., 2016). The same applies to children from lower socio-economic strata who benefit from ICT and cooperative learning approaches (Ke & Grabowski, 2007).

While it is positive that low-performing children are the beneficiaries of digital resources, the question is whether they are privileged to have such assets at their individual disposal and whether they receive adequate social support when needed. When those most likely to benefit from digital technology are least likely to have it, the implications of the digital divide are even more ominous (Jackson et al., 2007). Besides, family socio-economic conditions influence the quality of children's use of digital

technology. However, the current scenarios do not seem to be in favour of underprivileged children (Camerini et al., 2018; Gunduz, 2010; Xiao & Sun, 2022). These empirical observations have profound social implications beyond children's rights, learning and well-being.

The analysis in the preceding sections shows that children's use of digital technology is mediated by a wide range of factors such as (family) socio-economic and demographic characteristics, social resources, digital experience and skills, and motivation. In particular, children with lower socio-economic backgrounds use digital technology for entertainment and communication purposes while their well-off counterparts use such assets for educational purposes. The entertainment uses of digital technology include surfing on social media, talking on the telephone, using a smartphone, watching television and movies, leisure computing and playing popular (video) games on the internet, and these are found to create adverse effects on school performance. Non-educational uses of digital media substitute time for more meaningful tasks and promotes sensation-seeking and school-related problems including poorer academic performance. Children who receive adequate guidance and supervision in digital technology use have higher possibilities of experiencing positive outcomes in digital self-efficacy and learning outcomes. Perceived social support in digital media use and parental involvement in children's school-related tasks facilitate both digital and offline outcomes.

The quality, duration and intensity of academically useful computing activities are positively correlated to academic achievement. This includes both academic and non-academic outcomes. The former includes STEM benefits, foreign/second language learning, reading, and writing achievements and higher test scores (GPA/Percentage) while the latter incorporates motivation, reasoning and critical thinking, study skills and meta-cognitive skills. The non-academic benefits also include improved self-esteem and learner agency/autonomy. Similarly, entertainment use of the screen and digital platforms negatively predicts academic performance irrespective of socio-economic and socio-demographic characteristics.

ICT affects boys and girls differently. Girls experienced higher benefits in STEM learning compared to boys, which are conventionally "reserved" courses and career areas dominated by the latter. Despite the fact that children as young as six years old hold stereotypes that girls are weak in STEM learning (see Master et al., 2017), current evidence shows that girls involved in carefully designed ICT-integrated learning platforms demonstrated similar interest and self-efficacy in programming as boys and higher interest and self-efficacy compared to girls who did not participate in the programme. Thus, gender-inclusive ICT practices help to sustain girls' motivation, which is crucial for improving their STEM attitudes.

Low-performing children irrespective of gender gain positive learning outcomes from digital technology intervention more than high-performing peers. The teacher's role is significant in providing learners with individualized instruction and immediate feedback and creating a cooperative learning environment, which provides learners with the opportunity to enrich each other. This approach facilitates the learners' agency and provides them with the sense of being valued and recognized by teachers and fellow learners. When learners feel valued, they engage more meaningfully in tasks and take greater responsibility to accomplish them. Significantly, ICT integrated with cooperative learning helps to minimize adverse effects of lower socio-economic status and students' gender. Although research is scarce, the available evidence shows that children with low-metacognitive skills and learning disabilities gain higher benefits from teacher-led computer-assisted instruction. However, high-performing learners are observed more efficient when they worked independently.

In the next chapter, I will discuss these findings drawing on notions of digital divide, agency, and actor-network theory. The aim is to shed some light on how digital technology uses are mediated by different *actants* and create different landscapes of experiences and outcomes among the so-called digital natives.

6. Discussions

Different facts and figures presented in the introductory sections establish that access to digital technology and media no longer appears to be a privilege reserved for families with higher incomes (Chaudron et al., 2015; Livingstone et al., 2015). However, inequalities concerning digital media use are widespread among children (Chaudron et al., 2015; Hargittai, 2010; Livingstone et al., 2015; Selwyn, 2009) who are popularly represented as "digital natives" (Prensky, 2001), Z-generation (Amiama-Espaillat & Mayor-Ruiz, 2017) or net-generation (Hargittai, 2010). Drawing on the socio-material perspective and ANT (Callon & Latour, 1981; Latour, 2005; Law, 1992), the literature review documents that those inequalities are mediated by actants in children's assemblages consisting of heterogenous materials and dynamic interactions and relationships with them (see Ben-Youssef et al., 2022; Lei, 2010). This shows the complexity of how children's digital use, learning experiences and outcomes are mediated by different factors in the assemblages, creating different outcomes (Woods & Hammersley, 2017). As discussed in the previous chapter, family socio-economic and socio-demographic factors, social and cultural capitals, resources available in schools and skills and motivation of children themselves mediate their digital self-efficacy and digital capital. Children's digital capital further determines the quality of their engagement with digital platforms and resources, which influences their academic outcomes.

A plethora of evidence in the current review emphasizes relationships between family socio-economic status (e.g., social, economic, and cultural resources) and children's digital media use (Gunduz, 2010; Wong et al., 2015; Zhang, 2016). Even when internet access is ubiquitous, children from underprivileged backgrounds appear to engage in digital activities that are focused less on information or learning and more on entertainment, which does not translate into improved academic achievement, cognitive or socio-emotional skills (Fairlie, 2016; Malamud et al., 2019). Several experimental and cross-sectional studies document that academic impacts depend on the different actants enrolled in a certain network (Burušić et al., 2021; Koivusilta et al., 2007; Lei & Zhao, 2007; Mo et al., 2013; Mössle et al., 2010; Poulain et al., 2018; Robinson et al., 2018; Sharif et al., 2010). This finding is consistent with additional studies, which are not part of the current review (e.g., Livingstone et al., 2021; Salomon & Kolikant, 2016). It should, however, be noted that some studies report similar patterns in digital use irrespective of external factors (Fairlie, 2016; Hofferth & Moon, 2012).

Furthermore, an analysis of children's digital media use shows that their engagements with leisure/entertainment or non-academic activities are intense in disadvantaged families with immigrant backgrounds, lower education, and social and income prospects in adulthood (Camerini et al., 2018; Kent & Facer, 2004; Koivusilta et

al., 2007). Several studies find parents' involvement in mediating, guiding and supervising children's screen time positively associated with technology self-efficacy and educational outcomes (Burušić et al., 2021; Camerini et al., 2018; Lei & Zhou, 2012; Meza-Cordero, 2017; Wright, 2018). Some additional studies support the view that factors like digital skills, parental mediation and social support positively influence the quality of online experiences and opportunities for children and adolescents (Cabello-Hutt et al., 2018; Courtois & Verdegem, 2016). On the contrary, when children lack such resources at their disposal, they seem to displace time for educational activities by time on "consumeristic and entertaining activities, which not only seem to impede learning benefits but also decrease school grades as a form of learning outcomes" (Camerini et al., 2018, p. 2500). To put it in a theoretical perspective, children from privileged backgrounds produce academic benefits from the assemblages of heterogenous materials, not available to their disadvantaged peers. This suggests the human is de-centred, becoming just one of many actants enrolled in a constant flow of networks associated with technology use and learning outcomes (Lawn & Grosvenor, 2005), hence, the other actants are not necessarily at his or her disposal. Also, this suggests a shift in understanding that academic achievement is purely a cognitive performance limited to an individual child's stake. Several studies support this view, discarding preoccupation concerning an individual learner, teacher or technology (Fenwick & Landri, 2012; Tietjen et al., 2023; Zamecnik et al., 2022).

Nonetheless, low-performing children compared to high-performing counterparts irrespective of gender improve academic and non-academic outcomes from the use of digital technology in schools. Different experimental studies show significant learning gains from well-informed ICT interventions that created meaningful spaces for deep exploration, collaboration and knowledge sharing with fellow learners (Bacelo et al., 2020; Cadamuro et al., 2020; Li & Chu, 2021; Pruet et al., 2016; Shin et al., 2012). This applies to children struggling in schools due to learning disabilities and low-metacognitive skills (Cadamuro et al., 2020; Gulek & Demirtas, 2005). This shows, amongst other things, that the contents of ICT interventions also are actants, impacting the assemblages and the outcomes for the children enrolled in them. This includes roles played by teachers while creating conducive learning where learners work with tools and materials and take charge of their learning (Ale et al., 2017; Ellison & Drew, 2020; Mora et al., 2018). Moreover, in assemblages where certain kinds of projects like cooperative, collaborative or project-based learning are enrolled, senses of interest, autonomy and co-creation seem to emerge among learners (Crook et al., 2015; Li & Chu, 2021).

Besides, ICT-supported individualized instruction allows personalized progress by placing a learner in an independent and threat-free situation, which increases learning gains (Sung et al., 2008). A recent review affirms positive outcomes associated with

these approaches in gamified learning platforms (Huang et al., 2022). This means effective use of ICT in learning might help minimize adverse academic effects experienced by underprivileged children from lower socio-economic backgrounds (Genlott & Grönlund, 2016; Starkey & Zhong, 2019; Wong et al., 2015; Zhang, 2016). For these reasons, it is impartial to suggest that when certain specific actants, i.e., learner-friendly spaces and approaches, are enrolled in an assemblage, the emotional costs seem to decrease, which creates positive learning experiences for them. This is because when emotional costs increase, learners are more likely to develop anxiety and negative attitudes towards the (STEM) learning (Ball et al., 2019; Huang et al., 2015).

Conventionally, STEM subjects are perceived to be difficult and female students are at a greater academic disadvantage in this domain. However, interventional studies show that female students benefitted from ICT use either more or parallelly with their male counterparts (Burušić et al., 2021; Crook et al., 2015). These scholars argue that the educational use of OLPC added learning resources and substituted time otherwise used for entertainment. Additional studies affirm that female students benefitted more from advanced learning technologies because they followed the tutoring system more productively (Arroyo et al., 2013). One significant trend can be observed in these studies, that is that in assemblages with girls, social support and gender-inclusive digital platforms seem to be resulting in change, while in assemblages with boys, these seem to be only intermediaries (Arroyo et al., 2013; Heemskerk et al., 2009). Seemingly less important than providing girls with new learning platforms, they responded positively to female characters in learning materials, which worked as pedagogical agents (actants) that encouraged efforts and perseverance (Arroyo et al., 2013). Moreover, positive outcomes in the STEM domain following ICT intervention are significant towards mitigating STEM-related stereotypes held by children and bridging gender gaps in academic performance and future career opportunities (see Master et al., 2017).

However, the academic achievements of high-performing learners do not necessarily improve following ICT use (Cadamuro et al., 2020; Ferrer et al., 2011; Park et al., 2009; Sung et al., 2008). This is irrespective of the socio-economic and socio-demographic characteristics of the learners. Some studies even suggest that high-performing learners might experience learning loss from ICT-supported instruction and collaborative learning (Pruet et al., 2016; Wang, 2016), see Robinson et al. (2018) for an exception. Although there is limited evidence, some studies provide possible explanations that those learners effectively utilize previous knowledge and experiences to construct new learning independently (Bai et al., 2016). Besides, when educational interventions do not address the learning preferences and expectations of brilliant students or provide little autonomy in learning, they may demonstrate a reluctance to put effort into the learning (Cera Guy et al., 2019; Gajderowicz et al., 2023). Again, this highlights the

significance of inclusive learning spaces that are responsive to the learning needs and preferences of the learners.

Unlike popular discourses – that digital technology use either improves or hinders learning – the discussions above identify that there is no direct causality between these phenomena. Moreover, the conflicting accounts concerning digital technology use as either beneficial or harmful are like black boxes, which need to be opened to observe and examine the complexity of their interactions and relationships mediated by different actants in the assemblages in which children are embedded. How these are performed concerning digital use and why some children, for example, end up choosing entertainment over educational content or vice versa should be studied. The evidence shows that the different actants enrolled in the assemblages, such as socio-economic and socio-demographic factors and social and educational support (i.e., parents, teachers and fellow learners) influence the quality of digital use. This means that various offline capitals determine children's digital capital, which affects their academic outcomes. Though the current findings indicate that children with poorer academic backgrounds benefit from effective digital interventions in schools, the poor supply of learning materials and teachers and the lack of support mechanisms challenge the sustainability of the interventions, assemblages, and academic improvements (see Ansell, 2017; Wyness, 2019).

When children lack durable and dependable actants at their assemblages, it is more likely that their exposure to digital technology does not help them exercise full-fledged and active agency, which would otherwise do. As suggested by Charteris and Smardon (2018), assemblages of heterogenous materials produce and re-produce children's (active/passive) agency and digital and academic inequalities.

7. Conclusion, Implications and Limitations

In this concluding chapter, I reiterate the major insights developed through the literature review. It includes my reflections on the use of socio-material perspective as the analytical framework in review, emerging research trends and the overall review process. Besides, it suggests implications for research in childhood studies and education, and practice in different learning contexts. The chapter ends with some reflections on the potential and challenges associated with the study.

7.1 Conclusion

The review suggests that different socio-economic and demographic factors influence children's interactions and relationships with digital technologies. Children from disadvantaged families use digital platforms, mostly, for non-educational purposes while their privileged counterparts use similar resources for learning and development. One reason is that assemblages consisting of human and non-human materials aggregate to create a cultural environment for children that helps them make informed choices with digital technology. This means the privileged children receive adequate support to translate/capitalize those means into meaningful learning activities. As a result, they experience higher digital self-efficacy and academic achievements compared to their underprivileged peers. This entails the significance of various actants in the assemblages, in which non-humans bear the capacity to change the "size" of the actors, here children's academic achievements. Thus, this supports the view that materials have capacities to change the actions actors perform (Callon & Latour, 1981; Latour, 2005; Sørenssen & Franck, 2021).

In other words, children with adequate human and non-human materials at their disposal benefit from the assemblages, which might be out of reach for disadvantaged children. Nevertheless, currently available evidence shows that children with poorer academic backgrounds improved their performance after their enrolment in different interventions. If we are to consider the interventions as assemblages, they suggest the meaning that the new assemblages designed for children provided them with choices in learning and academic development, which were not available without interventions. Then, this leads to significant insights that digital interventions are powerful assemblages, which help decrease adverse academic effects likely to be experienced by disadvantaged children and low-achieving learners in different contexts. It should be noted that the digital interventions addressed the learning needs and interests of the low-achieving learners more effectively than the regular lessons they received in schools. In other words, children experienced more academic agency when they received additional learning support via digital interventions consisting of various actants i.e.,

technology and tools, new learning materials, methods and approaches, interveners/teachers, and learning platforms. Therefore, children's improvement in learning should be seen as a cumulative capacity transferred to them through different actants at their disposal. When interventions enrolled more robust and effective actants in their assemblages, they provided more learning agency in academically disadvantaged children. It is equally important to note that these children would hardly benefit had they been only provided with digital devices or enrolled in regular classes with conventional teaching-learning practices. This highlights the mediating roles played by various actants while appropriating digital use for academic gains.

This leads to the conclusion that children with poorer academic backgrounds and prospects require additional support systems in order to realize the technological potential in learning. While the cultural environment appropriates the digital use of privileged children, underprivileged children need (external) interventions to fill the gap in their assemblages and to create a similar learning environment as their peers. The study also supports the view that socio-economic inequalities create inequalities in digital skills and usage (Van Deursen & Helsper, 2015), which affect opportunities including academic learning among the so-called *Digital Natives, Net-gen or Z-gen (Livingstone et al., 2021)*. Thus, the study suggests that any lack of academic agency in children should be seen in the light of the assemblages at their disposal, not an individual moral project. As established earlier, children's learning involves dynamic collaborations. Academic agency, success or failure relies, heavily, on the quality of such collaborations rather than children's cognitive capabilities (see Woodhead et al., 2014; Wyness, 2015). Therefore, it is not faultless to assign children with the burden of academic failure.

Finally, the review highlights opportunities and challenges associated with digital use in educational settings. This creates opportunities because well-informed ICT interventions in schools and/or homes seem to help alter adverse effects likely to experience by disadvantaged children. ICT provisions in schools might complement teaching-learning in classrooms that are obliged to depend on old and torn textbooks. However, ICT intervention in classrooms is a distant future for schools, particularly in the Global South. When schools lack competent teachers and required textbooks for all learners, ICT provisions do not seem to enter classrooms any sooner. Thus, learning poverty and academic stratification will continue despite being surrounded by powerful learning resources. In this sense, the aspirations of the UNSDG 4 (a & 1) –providing effective learning environments to create effective learning outcomes for all (UN, 2015) are clearly challenged at present. While the study of social consequences of learning poverty is beyond the scope of the current review, what it shows is that children with lower socio-economic backgrounds and/or poorer academic performances will continue experiencing their rights undermined.

7.2 Implications for Future Studies and Practice

As the review builds on robust research benefitted from mixed methodologies and diverse groups of participants, I am confident that it provides critical insights for evidence-based policy and practice in fields that concern children's learning and rights.

First and foremost, as parents and teachers are assigned the primary responsibility to improve children's learning experiences, the new knowledge might be helpful to inform about the negative consequences associated with the non-educational use of digital media, which dominates children's screen time at present. This trend should be reversed if parents and schools expect better learning outcomes from children. When schools and parents collaborate, they can more efficiently guide and monitor children's digital media behaviours, which might eventually decrease the recent trend. Schools have the responsibility to equip children with (critical) digital literacy, which might help them mitigate adverse effects reproduced by digital divides in society.

Besides, the research in the field of childhood studies lacks evidence on how digital divides reproduce learning gaps and pave unequal terrain of opportunities in children's lives, also in the future as articulated by neo-liberal educational policies. If the field strives to advance in the new times, scholars in the field should reconsider their research orientations. Some opinion papers and editorials in the so-called dedicated journals do shed light on children's digital media behaviours, but the lack of field-based research shows the phenomenon of digital inequalities receives inadequate attention from the field at present. As figures 4.2 and 4.3 show, the field needs more research from Europe, Latin America, the Caribbean, Africa, and Australia. While China, India, Singapore and Taiwan host some notable studies, other countries in the region of Asia are yet to be represented in research that explores how digital inequalities are mediated and how they affect children's learning opportunities and academic outcomes. As children's screen time is ever-increasing around the globe, the field needs a global reach while exploring these phenomena.

I foresee potential with longitudinal field studies as short-term studies are constrained with time and resources required to observe and follow up the actors/actants for prolonged periods. This is because interventions do take time to generate outcomes, which is difficult to document in short field visits. In addition, longitudinal studies might provide insights into the sustainability of the outcomes. Future studies might benefit from mixed methodologies as they help to explore not just perceived but measurable outcomes of digital use.

This is significant because children's use of different digital technologies has profound social implications across contexts; thus, research cannot be limited to a region, methodology, gender or ethnicity. Moreover, understanding how children's participation in digital environments is critical towards improving their material

conditions. Participation does matter as it creates opportunities to foster creativity and collaboration through different digital platforms while keeping pace with others who are growing digitally. However, tangible outcomes of such participation matter more as they involve consequences here and now, but also in future. As one of the main tenets of childhood studies is the concern for children's lives, it is timely to explore how children's "scholarized lives" (see Kjørholt, 2013; Olk, 2009; Qvortrup, 2009) and experiences are shaped by the assemblages consisting of human and non-human materials, learning spaces, social norms and policies.

Likewise, recognizing that children are competent and agentic beings does not necessarily mean they have the capabilities to navigate challenges linked to digital media. At least, the currently available evidence in the social sciences shows children from diverse socio-economic and demographic backgrounds appropriate digital technologies differently, which creates inequalities in academic outcomes as discussed earlier. This means both human and non-human actors (actants) take part in appropriating digital use and creating meaningful learning spaces for children, which might be observed in their tangible academic achievements.

7.3 Limitations of the Literature Review

The review has some limitations. One of them is related to the methodological constraints of some studies that present difficulty in demonstrating the causality of the observed effects (e.g., Ale et al., 2017; Ferrer et al., 2011; Mora et al., 2018). This applies to studies that are built on quasi-experimental, non-randomized and flexible designs. Likewise, some scholars acknowledge challenges associated with the assessment of student learning, which is subject to change due to developmental outcomes rather than the use of digital technology (Lei, 2010; Shin et al., 2012). In addition, a few studies are conducted with limited research participants making it difficult to generalize the findings to broader contexts (e.g., Aliasgari et al., 2010; Bacelo et al., 2020; Ellison & Drew, 2020; Heemskerk et al., 2009; Huang et al., 2013; Tadayonifar & Entezari, 2020; Wang, 2016). Some researchers are also critical of the sustainability of the impacts of digital interventions reported in their studies (e.g., Master et al., 2017; Pruet et al., 2016). Also, issues related to self-reported media use, its patterns and the lack of evidence on why children choose to consume some media abandoning others are revealed in the original research (see Malhi et al., 2016; Zhang, 2015). Besides, the review builds on studies of diverse groups of children who represent different views and meanings concerning academic achievement. Though children's academic development is a global concern, it nevertheless holds different significance in different contexts of the Global North and the South. This may have some implications for designing and implementing interventions and assessing the learning impacts in schools.

In the same way, the attempts to extend the utility of ANT in review pose challenges in the sense the studies included in the review provide limited insights about the assemblages significant in determining the Third Digital Divide and academic achievements among children. Although notions of ANT are useful to "follow" and analyse the associations between the actants, the new knowledge lacks in-depth insights about why some actors add on their agency by using digital technology while their peers fail to do so. This is partly linked to difficulties associated with digital inclusion research that lacks reliable and valid measures to explain the complexity of (dis)advantageous assemblages and outcomes (Van Deursen & Helsper, 2015). Nevertheless, ANT might be a way forward for different research seeking to understand the complexity of children, digital use and academic outcomes and furthermore build a comprehensive understanding of how children's learning experiences are mediated and shaped through the involvement of a wide range of actants, leaving simplistic conclusions of causality behind.

To my knowledge, the dominating body of research linked to digital technology use and learning employs different theoretical and analytical constructions such as the theory of capital, mobile learning, online learning, flipped learning, computer-assisted/supported/integrated learning, structuration, constructivism, agency, displacement, etc. ANT might be able to open up, nuance and show the complexity, and might help overcome inconsistencies and incompatibilities probable while drawing on multiple theories for a single study. In addition, the limitations associated with some value-laden theories, for example, technology-enhanced learning, innovative learning, and transformative learning might be addressed using notions of ANT, as it creates spaces for exploring the social origins of children's academic achievement.

As childhood studies embrace socio-cultural constructions of childhoods and are sensitive to children's material realities, ANT seems promising to help decentre the focus of analysis from children's cognitive capacities and/or technology to socio-technical assemblages which determine agency and experiences. Regardless of these critical insights, techno-solutionism will continue its "business as usual", and children will continue spending several hours a day in front of screens, demanding our continued scrutiny (see Selwyn, 2023a; Selwyn, 2023b). As argued by different scholars in education and childhood studies, for example, Fenwick et al. (2015), Spyrou (2019, 2022), Sørenssen and Franck (2021) and Selwyn (2023b), among others, I see the potential of employing a socio-material perspective to study how different assemblages make learners (and teachers) perform in the way they do in diverse contexts. This again has implications for academic outcomes, neoliberal schooling and society. However, it should be noted that the use of these analytical concepts in reviews is not free from limitations, one of which is the lack of in-depth insights into how interactions and

relationships between different actants unfold in particular socio-material and cultural contexts.

To put it in a nutshell, childhood studies might benefit also from similar systematic reviews, which positively respond to the call for interdisciplinarity in the field (see Alanen, 2011; Spyrou, 2011; Thorne, 2007). Reviews allow integration of the achievements and evidence across-disciplines (James, 2010) that reflect the change experienced by children across age, gender, communities and regions. This might be an opportunity to address analytical limitations that assign uncritical agentic capabilities to children, leaving other actants/elements unanalysed (see Hammersley, 2017; Spyrou, 2019). Future research in the field needs to continue reflecting on these possibilities and limitations.

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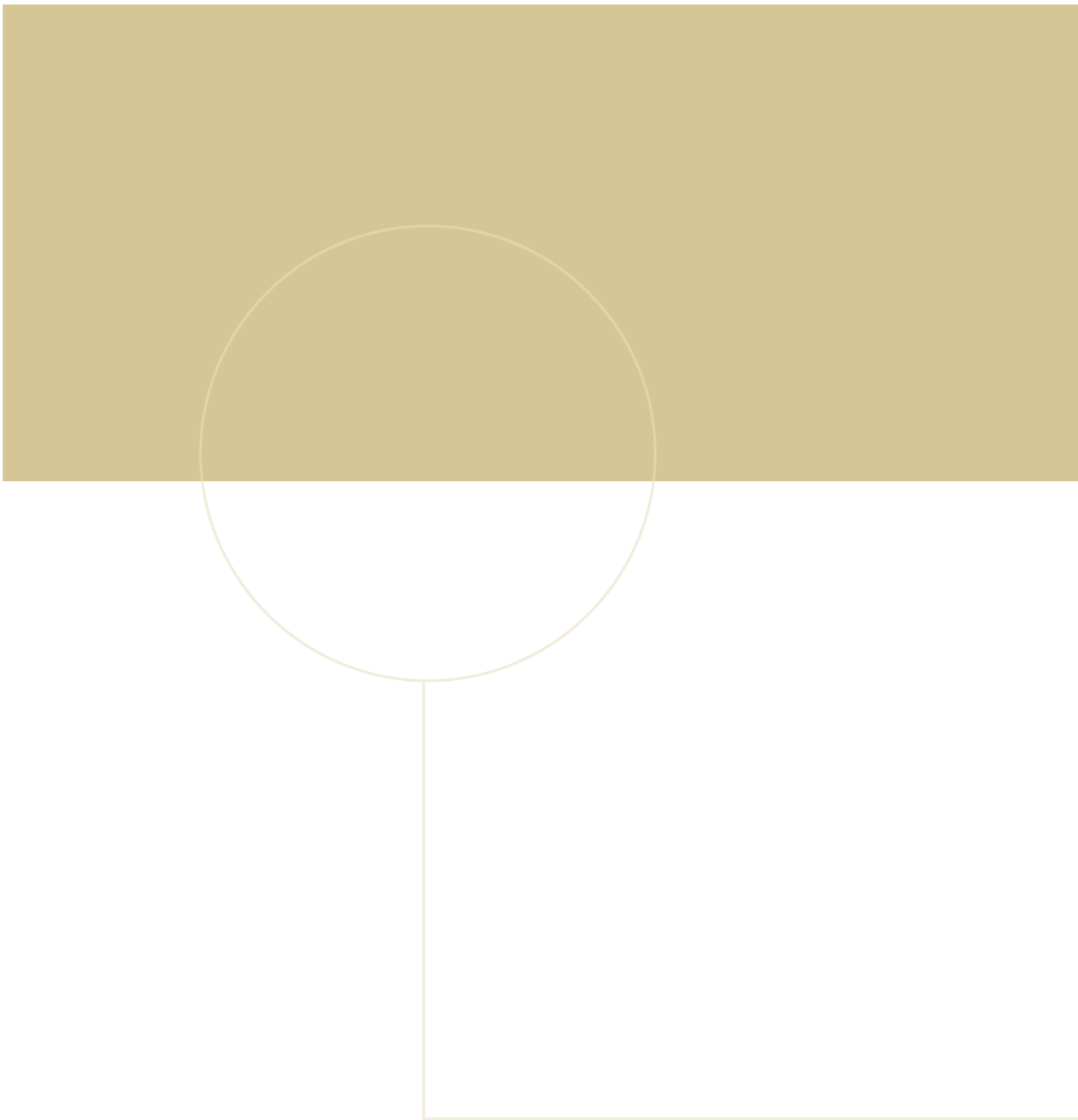

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