

Visualizing the Complexity of Children's Digital Well-Being in South Korea: A Systems Thinking Approach Based on the Systematic Literature Reviews

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Abstract

Background In response to the increasing prevalence of digital interaction in daily life, the concern regarding digital well-being is escalating, especially for Generation Alpha. Framing the issue of Generation Alpha's digital well-being as a complex problem, this study aims to analyze and describe its complexity from a systems perspective.

Methods This study conducted systematic literature reviews and thematic analysis to achieve an overview of existing literature and related themes on children's digital well-being in South Korea. The results were then translated using concept mapping, a systems-thinking-based visualization tool, to identify and describe the interconnections and relationships among the issues related to children's digital well-being.

Results We found four main themes within the study on Generation Alpha's digital well-being in South Korea: causes/factors that affect digital well-being, effects of digital interactions on well-being, factors of digital well-being, and solutions/initiatives to improve digital well-being. Correlations existed among the themes, which were represented using concept mapping. The mapping also revealed research gaps and future research opportunities.

Conclusions This study reports the current research landscape on Generation Alpha's digital well-being and demonstrates the complexity of the issues found in the literature using concept mapping. The concept maps can effectively communicate the complexity embedded in design challenges thereby helping designers and stakeholders approach them from a systems perspective and identify opportunities for future design solutions.

Keywords Digital Well-Being, Complex Problem, Systems Thinking, Visualization

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1. Introduction

Although digital media and devices play a variety of positive roles in our daily lives by providing education, entertainment, and convenience, there has been growing concern over the use of digital devices. Catalyzed by the shift in the relationship between humans and digital products, digital interaction has evolved to such an extent that its pervasiveness and speed impact human well-being (Verbeek, 2005). This is especially relevant to Generation Alpha, those born after 2010 who have lived their lives integrated with digital devices since a very young age or even infancy, being part of the group of digital natives. Various studies have highlighted the negative impact of smart device overuse which can affect various aspects of children's quality of life (QOL), including physical health, mental health, social interaction, overall happiness, and overall QOL (Jeong et al., 2019; Lee and Lee, 2021; Moon et al., 2016). In particular, these impacts are evident among elementary school students in South Korea, who are now part of Generation Alpha. Korean elementary school students have the lowest life satisfaction levels among the Organization for Economic Cooperation and Development member countries, a fact strongly affected by the overuse of digital devices (Lee and Lee, 2021), and 37% of South Korean children and adolescents aged 10–19 have been found to be overdependent on smartphones (Kan, 2022). In this context, there is a growing demand for understanding this cohort and the problems it experiences in depth and comprehensively, which led to the introduction of 'digital well-being'. Digital well-being is a highly subjective notion since the context and one's environment can significantly affect how one interacts with technology (Cecchinato et al., 2019). It is a complex problem to deal with due to the presence of multiple intertwined and conflicting premises (Vanden Abeele and Nguyen, 2022; Valasek, 2022).

Tackling a complex problem is challenging, as it typically does not have concrete solutions and can exceed one's processing capabilities (Öllinger et al., 2015). To mitigate this challenge, tools such as external representation can assist in the decision-making process (Öllinger et al., 2015; Zhang, 1997). Moreover, in recent years, design has evolved and is often utilized in tackling complex problems, especially through systems thinking, which enables designers to analyze complex systems (da Costa Junior et al., 2019). Considering the complexity of children's digital well-being, it is necessary to examine it through a systems perspective to allow a better understanding of the problem, which consequently can result in better-adapted design solutions. However, research has tended to focus only on a singular aspect or relationship within the issue, as they originate from such specific fields as psychology, health, and child studies; hence, they fail to examine the issue as a whole at a systemic level. In this context, our research questions are: (1) how complex are the issues surrounding children's digital well-being and how do we communicate them; and (2) what implications do our findings have in addressing children's digital well-being from a systems perspective? To answer these questions, we conducted a systematic literature review to offer an overview of South Korean Generation Alpha's digital well-being and understand this issue from multiple perspectives by reviewing existing literature and related themes on the topic from relevant domains and disciplines. We employed a systems perspective in analyzing and visualizing the relationships of these issues to examine potential patterns and relationships among them.

Lastly, we discussed how our approach to systems-thinking-based visualization contributes to the design for children's digital well-being.

2. Digital well-being

Digital technologies offer both benefits and harms to people's well-being. The benefits include improved work productivity (Monge Roffarello and Russis, 2021) and hedonic and eudemonic experiences, resulting in the improvement of well-being (Henderson and Knight, 2012; Vanden Abeele, 2021). There are also harms, for instance, when phone use interferes with social activities (McDaniel and Drouin, 2019), distracts from work and study (Duke and Montag, 2017), leads to procrastination (Schnauber-Stockmann et al., 2018), causes sleep and health problems (Lanaj et al., 2014), and induces negative emotions such as emotional exhaustion and anxiety (Büchi et al., 2019). As a recently emerging concept, digital well-being has a variety of definitions and understandings. Nevertheless, there is a consensus that a healthy relationship with technology is needed that balances its benefits and harms (Büchi, 2021; Vanden Abeele, 2021; Yue et al., 2021).

3. Systems thinking for complex problem-solving

A complex problem is characterized by five attributes: a large number of variables; considerable connectivity between the variables; the existence of multiple, often conflicting goals; the dynamicity of the situation, which changes over time; and the intransparency of the situation (Burmeister, 2009; Dörner et al., 1983; Funke, 2001, 2003, 2012; Fischer et al., 2012; Öllinger et al., 2015). These attributes are also found in issues related to children's digital well-being. First, numerous factors—individual, socio-cultural, economic, and political—influence individuals' digital well-being directly and indirectly (Vanden Abeele and Nguyen, 2022; Valasek, 2022). These factors act as variables that exist within the system, influencing the individuals and their behavior, and shaping the system's flow and resulting outcomes. Besides, various studies have identified causal chains within digital well-being (Büchi, 2021; Byrd, 2020), conveying the strong connectivity between variables. Third, there are multiple and often conflicting goal states recommended by different literatures. For instance, poor digital well-being and lack of self-regulation are caused by devices' addictive design, which thus requires people to disconnect and abstain from digital devices to achieve a positive state of well-being (Vanden Abeele and Nguyen, 2022). However, in the current age of technology, it is not realistic for individuals to fully disconnect from technology as daily, fundamental tasks also require digital devices, same as social interaction, workplace demand, and education; this thus results in conflicting goals. Fourth, dynamicity is prevalent in digital well-being. Technology is constantly evolving to improve convenience and QOL, its role in daily life continues to change and consequently impact digital well-being positively and negatively. Lastly, the variables of digital well-being and their interactions are often not visible to decision-makers such as designers/researchers, educators, parents,

and policymakers on the surface. In short, considering the number of variables, non-linear relationships that are intransparent, and the dynamic nature of the issue that exists within digital well-being, it can be considered a complex problem.

A complex or wicked problem (Rittel and Webber, 1973) is constantly evolving, multifaceted, and interconnected. It requires the involvement of various stakeholders and holistic observations to avoid oversimplification (Suoheimo, 2020). Moreover, the problem-solving process of a complex problem has to be studied as a whole because the factors are highly intertwined, interacting, and influencing each other, making it difficult and inappropriate to examine them in isolation (Fischer et al., 2012). This principle aligns with the concept of systems thinking, which perceives complexity in terms of interconnected wholes and relationships, rather than breaking it down into isolated components for analysis (Ramage and Shipp, 2009).

Systems thinking is a problem-solving approach capable of handling the inherent complexity of societal problems as it allows designers to adopt a holistic perspective through a specific set of assumptions, premises, and axioms. It also has the potential to incorporate differing world views (Blizzard and Klotz, 2012; Clegg, 2000; Cardenas et al., 2010; da Costa Junior et al., 2019; Daellenbach, 2001; Forlizzi, 2012; Jackson, 2003; Jackson and Keys, 1984; Jones, 2014). Therefore, framing children's digital well-being as a complex problem and approaching it from a systems perspective would allow for a more comprehensive and holistic approach to understanding the current reality and tackling problems.

4. Method

4. 1. Systematic literature review

We conducted a systematic literature review on the digital well-being of South Korean Generation Alpha. The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses; Moher et al., 2010) search protocol was employed. Three databases were used for the literature search: Scopus, Google Scholar, and Korea Citation Index (KCI). The year of publication was restricted to 2010 onwards, which marked the start of Generation Alpha. In the international database, the search keywords were: (“Korea” AND “children”) AND (“digital well-being” OR “digital media” OR “gaming addiction” OR “internet” OR “media literacy” OR “digital literacy” OR “digital device” OR “smart device” OR “smartphone”), which resulted to 357 results in Scopus. The Korean literature keywords consisted of the translation or corresponding Korean terms for the English keywords, which in total yielded 282 results from KCI and 50 from Google Scholar. However, it is important to note that in light of the large amount of literature retrieved through Google Scholar that ended up not being relevant to the topic, the keyword search was limited to only the titles of the studies. A total of 689 papers were initially identified. However, as Generation Alpha would have started attending elementary schools in 2016 at the earliest, the publication year was further restricted to 2016 onwards. After removing studies published prior to 2016 and duplicates, the number of articles was reduced to 375. The first screening filtered the articles based on the relevancy of

the title, which removed 181 studies along with 12 unretrievable papers. The second screening removed 135 articles based on the abstract. Finally, by looking at the participants and data collection, studies involving participants who did not fall in the age range of school-aged Generation Alpha were removed, resulting in 44 studies for further analysis.

4. 2. Thematic analysis

To analyze the content of the retrieved literature, a thematic analysis was conducted. We used open coding to retrieve as much information as possible without limiting barriers, followed by axial coding to find the kinds of topics or purposes that the existing literature addresses regarding children's digital well-being in Korea in recent years (Williams and Moser, 2019). The thematic analysis employed in this study was first done by reading the content, where the important findings were highlighted and transformed into meaning units. These meaning units were then derived into more condensed codes, grouping similar findings. Lastly, by looking at the extracted codes, the main themes of the findings were identified. As a result, we identified four main themes of research topics on children's digital well-being in Korea.

4. 3. Concept mapping

The findings from the systematic literature review and thematic analysis were then mapped using concept mapping. Concept mapping is a visualization tool used in systems thinking to synthesize and interrelate knowledge and to promote a shared understanding of the system among stakeholders (Burke et al., 2006; Trochim and Cabrera, 2005). Concept mapping has been shown to be effective in assisting the learning of complex systems (Tripto et al., 2013) and applied to various studies that tackle complex systemic issues such as health services research (Alafaireet et al., 2015) and public health (Leischow et al., 2008; Trochim et al., 2006). Concept mapping usually employs a participatory approach where multiple stakeholders are gathered to discuss and create the map together. However, this study used a systematic literature review from multiple disciplines, representing various stakeholders' views. The maps thus created would include empirical findings that can be used as a baseline for an initial understanding of the system and future participatory design activities.

5. Results

The thematic analysis described above identified four key themes: effects of digital interaction on well-being, causes/factors that affect digital interaction, factors of digital well-being, and solutions/initiatives to improve digital well-being. Table 1 lists the reviewed literature according to these four themes.

Table 1 List of reviewed studies organized by theme

Causes/factors that affect digital well-being	Cho, 2021; Han and Chang, 2020; Hong, 2022; Jeong et al., 2019; Ju, 2019; Kim and Kang, 2022; Kim and Jahng, 2021; Kim and Park, 2021; Kim and Choi, 2020; Kim, 2022; Lee et al., 2022; Lee and Kim, 2021a; Lee and Kim, 2021b; Lee and Mun, 2022; Lim and Jeong, 2022; Nam and Hwang, 2019; Oh et al., 2021; Oh et al., 2020; Park and Noh, 2019; Son et al., 2021; Song, 2022; Yoo and Choi, 2021
Effects of digital interactions on well-being	Ahn et al., 2017; Choi et al., 2021; Jeong et al., 2019; Kim et al., 2020; Lee, 2020; Lee et al., 2022; Lee and Lee, 2021; Lee and Park, 2022; Moon et al., 2016; Park et al., 2022; Yoon et al., 2021
Factors of digital well-being	An and Kang, 2019; Eoh et al., 2022; Hong, 2021; Kim and Jung, 2021; Nam, C., 2021; Yang et al., 2021
Solutions/initiatives to improve digital well-being	Jo and Bang, 2022; Kim and Kim, 2019; Kim and Jung, 2021; King et al., 2018; Nam and Hwang, 2018

5. 1. Causes/factors that affect digital well-being

Causes/factors that affect digital interaction was the most popular theme, appearing in 22 articles. First, screen time was found to be a prevalent indicator of addiction and dependence (Lee and Kim, 2021a; Lee et al., 2022; Song, 2022). However, it was also pointed out that instead of screen time, the type of content/media and purpose of use has a more significant impact on addiction (Hong, 2022; Lee et al., 2022; Lee and Kim, 2021a; Oh et al., 2020; Song, 2022). Internal factors such as children's temperamental/risk type (Hong, 2022; Kim, 2022; Song, 2022), psychological aspects (including emotional stability; Hong, 2022; Kim and Jahng, 2021; Kim and Kang, 2022; Kim, 2022; Lee and Mun, 2022), playfulness (Kim and Kang, 2022), self-esteem (Lee and Kim, 2021b; Kim and Park, 2021), and mental health (Jeong et al., 2019; Kim, 2022; Lee et al. 2022; Lee and Mun, 2022) were associated with how they interact with and are affected by digital interaction. Meanwhile, external factors such as the economy (Lee et al., 2022), peer relationships (Ju, 2019; Kim and Kang, 2022), and coronavirus disease 2019 (COVID-19; Lee et al., 2022) were also contributing factors affecting children's interactions with digital devices to indirectly impact their digital well-being. Parents also influenced children's digital well-being through parental control (Cho, 2021; Kim and Choi, 2020; Lee and Kim, 2021b; Nam and Hwang, 2019; Park and Noh, 2019; Song, 2022; Yoo and Choi, 2021), parents' perceptions of digital devices (Lee et al., 2022; Nam and Hwang, 2019), parents' attitude/behavior toward the child (Cho, 2021; Kim and; Choi, 2020; Lee and Kim, 2021b; Lee and Mun, 2022; Yoo and Choi, 2021), family interaction/parent-child relationship (Han and Chang, 2020; Ju, 2019; Kim and Jahng, 2021; Lee and Kim, 2021; Lim and Jeong, 2022), parents' habits in using digital devices (Lee and Kim, 2021b; Lim and Jeong, 2022; Son et al., 2021), and parents' mental health (Lee et al., 2022; et al., 2021; Oh et al., 2021; Park and Noh, 2019). Additionally, parenting factors are often influenced by external factors such as economic stress and COVID-19 (Lee et al., 2022), further illustrating how external factors can indirectly affect digital well-being. Figure 1 presents the summary of the relationships among the causes/factors affecting children's digital well-being.

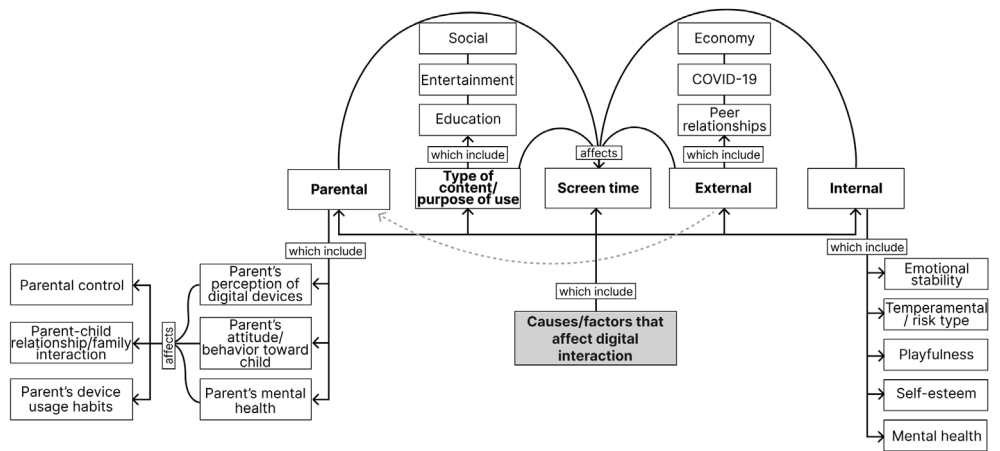


Figure 1 Concept map of the causes/factors that affect children's digital well-being

5. 2. Effects of digital interaction on well-being

Effects of digital interaction on well-being were identified in 11 articles, which mainly discussed the negative effects of problematic digital interactions, namely digital addiction, digital device overuse, and smartphone dependence, on children's lives, including internal and external behavioral problems, physical health, and overall QOL. Internal behavioral problems include psychological health, where significant connections were particularly found with children's depression and social atrophy (Ahn et al., 2017; Jeong et al., 2021; Lee et al., 2022), whereas external behavioral problems include aggression and attention problems or difficulty focusing during class (Ahn et al., 2017; Lee et al., 2022). Additionally, media-addiction-related external problems are also reflected in sensation-seeking and rule-breaking behavior (Choi et al., 2021). Internal and external behavioral problems and screen time are generally associated with social and academic adaptation, both consequently affecting school adaptation (Ahn et al., 2017; Choi et al., 2021; Lee and Lee, 2021; Lee and Park, 2022). Consequently, poor school adaptation can negatively impact academic and social aspects of children's lives, further exacerbating the problem and creating a loop. Furthermore, unhealthy relationships with digital devices can also be reflected in physical issues such as bad posture and eye-sight problems (Moon et al., 2016). Digital addiction can also indirectly cause additional health problems, such as lack of sleep and reduced sleep quality, leading to various health problems (Kim et al., 2020; Park et al., 2022; Yoon et al., 2021). Additionally, smartphone and media addiction tends to harm overall health, as it can lower health-promoting behavior due to low self-regulation abilities (Lee and Lee, 2021). Hence, the unhealthy and unregulated use of digital devices affects QOL as a whole, including physical, emotional, social, and academic areas. Figure 2 describes the interconnected effects of digital interaction on children's digital well-being.

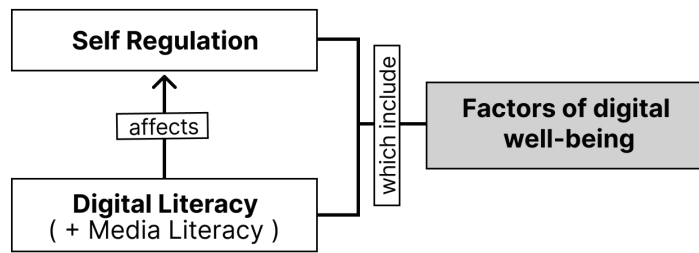


Figure 3 Concept map of the factors digital well-being

5. 4. Solutions/initiatives to improve digital well-being

Various studies offered solutions to tackle problems such as addiction and assessed existing prevention programs (Figure 4). For instance, an online literacy program (Kim and Jung, 2021) based on design thinking improved students' media literacy capabilities. A group art therapy targeted children's smartphone addiction based on the delay of gratification theory, that is, delaying immediate satisfaction of needs for a greater future good and enduring the spontaneous frustration of the delay (Kim and Kim, 2019; Mischel, 1974). The intervention showed effectiveness in increasing the participants' self-control and reducing the level of smartphone addiction (Kim and Kim, 2019). A peer support program designed to prevent smartphone addiction by enhancing peer relationships, reducing depression, and improving self-control in late school-age children was developed (Jo and Bang, 2022). It included group-based play and art activities to help late school-aged children to acquire social skills and interact with peers without using smartphones. Nam and Hwang (2018) explored parents' needs and preferences for intervention to reduce the risk of Internet addiction among children. They found that the initiatives developed and deployed by corporations and private firms tend to be less favorable, especially for customers with low digital literacy. Thus, they recommended that firms develop strategies to change and improve consumers' perceptions of corporate efforts (ibid.). Lastly, a review of the existing intervention in Korea found that the model of the Gaming Disorder Prevention Act is similar to the efforts to address public health threats, which includes extensive government initiatives and long-term strategic plans at all three levels of prevention: universal, selective, and indicated (King et al., 2018). The initiatives include policies, awareness campaigns, survey investigations, training programs, hospital care, prevention centers, counseling services, rehabilitation camps, and public education (ibid.).

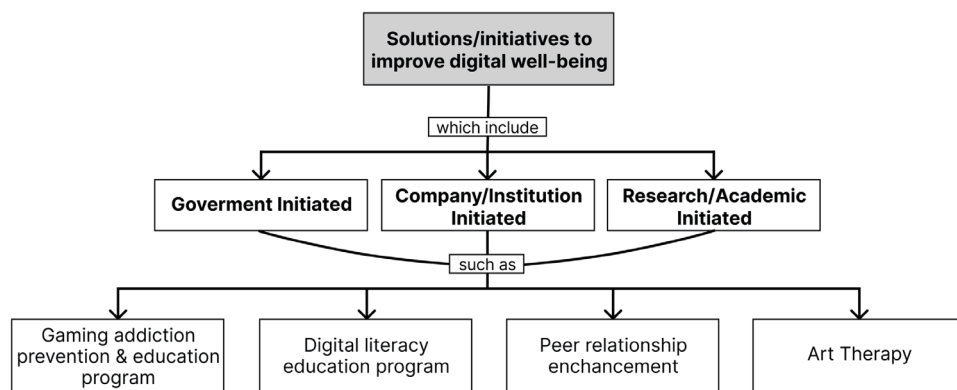


Figure 4 Concept map of existing solutions/initiatives to improve digital well-being

5. 5. Connection between main themes

Based on the concept mapping of each independent theme, we further analyzed their interactions, whereby they either target, cause, or are affected by other themes (Figure 5). First, *factors causing or affecting digital interaction*, such as screen time, internal & external factors, type of content, and parental factors, would produce *the effects of digital interaction on well-being*. This, combined with the lack of *digital well-being factors*—namely digital literacy, media literacy, and self-regulation—would often lead to the problematic use of digital devices and other adverse impacts such as physical health issues, internal/external behavioral problems, and problems in academic performance and social. For example, when children’s smartphone use is not regulated by their parents and the children themselves lack self-regulation abilities, their screen time tends to increase, which would likely result in dependence and overuse, and consequently lead to trouble in school adaptation and sleeping problems. To address the negative effect of unhealthy digital interaction, *solutions/initiatives to improve digital well-being* would be deployed to tackle this issue. Meanwhile, these *solutions/initiatives* would target the specific *causes/factors that affect digital interaction via measures to achieve the factors of digital well-being*. For instance, a peer-support program can mitigate smartphone addiction among children, improve peer relationships, reduce depression, and improve self-control.

In addition to the connections between the main themes, the sub-themes also have distinctive connections with one another. For example, factors affecting children’s screen time also exist in their parents. Parents’ digital literacy, media literacy, and self-regulation significantly impact their children’s digital well-being. These factors influence parents’ perceptions of digital media, thereby affecting how they control their children’s digital device usage. They also affect parents’ habits in using digital devices, which profoundly affects their children’s interactions with digital devices.

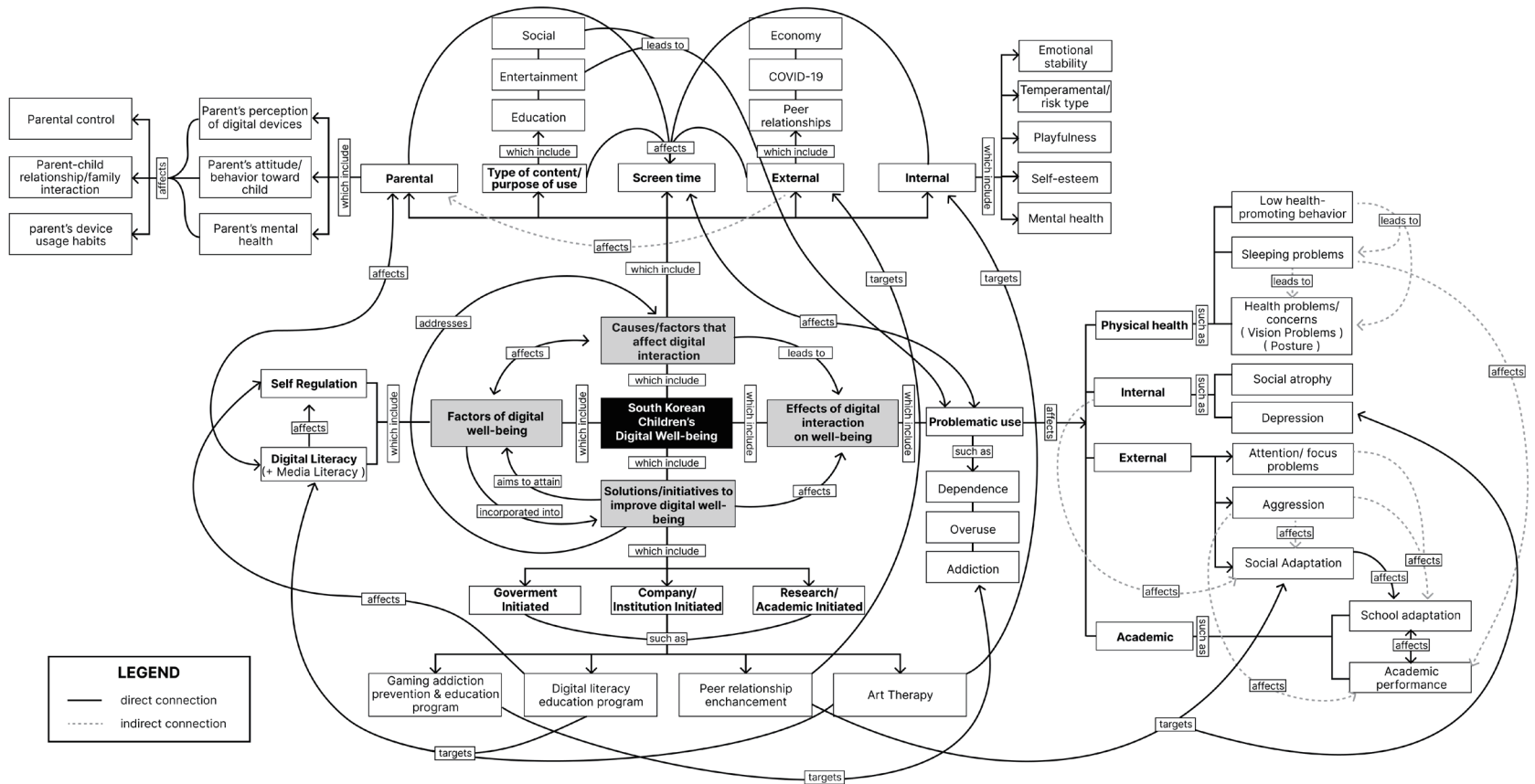


Figure 5 Concept map of the relationships in children's digital well-being (overarching theme in black box, main themes in grey boxes and sub-themes in white boxes)

6. Discussion

Concept mapping helps us discern the landscape of the extant studies and understand the complexity found in the issues related to generation alpha's digital well-being and their relationships. It is also useful for communicating to stakeholders the limitations of the conventional local approach and orienting them towards a more holistic and multifaceted one, i.e., creating an ecosystem of solutions that aim to make systemic changes at multiple leverage points. For example, Figure 5 helps us recognize that the children's screen time is affected by internal (e.g., children's emotional and mental status, personality, and level of self-esteem) as well as external issues (parents, peer relationships, education, digital contents, and the socioeconomic environments). According to the map, screen time will not be reduced – at least not in the long term – by enforcing disconnection and abstinence from digital devices, which is both simplistic and unrealistic. Instead, a multifaceted approach is needed that considers the internal, external, and parental factors and involves multiple actors including children, peers, parents, teachers and therapists. This understanding of complexity can inform designers and stakeholders of the need for a systems perspective in addressing screen-time reduction. It also guides them through identifying design opportunities and setting the direction of interventions.

The maps are useful in this regard also because they give an overview of the existing interventions. The nodes show how existing interventions aim to address specific causes and target specific factors, which suggests the research gaps and design problems to be addressed in the future. For instance, the art therapy (Kim and Kim, 2019) targets internal factors such as the child's temperament to improve their self-regulation, and the peer enhancement program (Jo and Bang, 2022) targets external factors, particularly children's peer relationship, to improve mental health and self control (Figure 5). Meanwhile, the digital literacy program (Kim and Jung, 2021) aims to improve children's digital literacy and self regulation. Similarly, the gaming addiction prevention and education program also aims to improve children's digital literacy, with the addition of specifically tackling the notion of gaming addiction. However, the nodes suggest that there is no intervention that specifically focuses on the type of content/purpose of use even if it is evident from the literature review that the type of content/media and purpose of use have a significant impact on addiction, where entertainment and social contents are more likely to cause dependence and overuse than educational content (Lee and Kim, 2021a, Song, 2022). Based on this observation, one may consider an intervention with goals specific to content type, such as redirecting smartphone use toward educational purposes.

Additional syntheses and interpretations can be derived from these maps as they serve as external representations, i.e., diagrams that capture and depict complex problems to help designers and stakeholders address them through decision-making and solution generation. Complex problem-solving requires a high level of cognitive functioning (Öllinger et al., 2015; Zhang, 1997). However, humans tend to resort to information reduction when coping with complexity, as large amounts of knowledge may overwhelm one's processing capabilities (Fischer et al., 2012; Klauer, 1993). External representation allows them to preserve cognitive

functions in assembling and encoding information (Kirsh, 2010) and minimize the tendency of oversimplification and information reduction (Fischer et al., 2012). That is, interacting with an external representation can assist in processing information more efficiently and effectively and helps people make sense of a complex structure (Kirsh, 2010). External representation can also serve as a tool in simulating modifications such as rearrangement, explicitly referring to and modifying elements, and visually comparing earlier and later structures (Kirsh, 2010), significantly improving the problem-solving process. Hence, visualization of a broad system encompassing various fields and perspectives can encourage designers and stakeholders to take a holistic approach to their decision-making process and improve the overall process and results.

7. Conclusion

This study used systematic literature reviews to report the current research landscape on the South Korean Generation Alpha's digital well-being. It also discussed complex issues addressed in the literature and demonstrated their interrelations using concept mapping. We found that the issues related to this generation's digital well-being manifest in the form of a complex system, and tackling them thus required investigation of their interactions across problem domains. However, extant studies tend to approach these issues from an analytic point of view, that is, in the context of specific problem domains rather than from a holistic one. This study is part of a longitudinal study on Generation Alpha in South Korea. This paper thus focuses on the digital well-being of this cohort. In this regard, our attempt to apply systems thinking and systems mapping to Generation Alpha's digital well-being is useful for bridging this knowledge gap. We also anticipate that our concept maps would reduce cognitive load in complex problem-solving and inform decision-making in future design endeavors. A limitation of this study is that we selected concept mapping based on our empirical knowledge rather than systematic reviews of systems mapping tools. While we found the concept mapping useful for our purpose, it also revealed limitations. For example, there is a lack of information about the relationships between elements, and a compromise between legibility and complexity had to be made. It hence remains as future work to develop a systematic approach that informs the selection of visualization tools for systems thinking and design based on their characteristics. Additional future works include applying systems thinking and visualization to advance children's digital well-being in designerly ways. For example, identifying research gaps previously overlooked in the derived themes and sub-themes and using them to develop a multifaceted approach involving multiple variables and actors.

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