

# VISUALIZING THE COMPLEX PROBLEM OF CHILDREN'S DIGITAL WELLBEING IN SOUTH KOREA: A SYSTEMS THINKING APPROACH

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## ABSTRACT

Considering the prevalence of digital interaction within the Generation Alpha, this study focuses on the digital wellbeing of elementary school-aged children in South Korea. By taking into account the multi-faceted nature, this study frames the issue that exists within children's digital wellbeing as a complex problem and aims to have a better comprehensive understanding of the system using a designerly and systems thinking approach. Thus, this study conducts a Systematic literature review and thematic analysis to get grasp of the current situation which then is translated using a systems thinking-based visualization tool to convey the causal relationships that exist within the system. Therefore, the outcome of this study presents a concept map that consolidates the findings to communicate a holistic perspective of children's digital wellbeing which can be used in design activities and decision-making processes which contribute to future design solutions and conversations.

**Keywords:** Digital Wellbeing, Complexity, Social responsibility, Visualisation, Societal consequences

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## 1 INTRODUCTION

Although digital media and devices have various positive roles in our daily lives by providing education, entertainment, and convenience, there has been a growing concern over the use of digital devices over the years. Catalysed by the shift in the relationship between humans and digital products, digital interaction has evolved to the extent where its pervasiveness and speed impact humans' well-being (Verbeek, 2005). This is especially relevant to Generation Alpha, who were born after 2010 and have lived their lives integrated with digital devices since a very young age or even infancy, being part of the digital natives. Various studies have highlighted the negative impact of smart device overuse which can affect children's quality of life in various aspects including physical health, mental health, social interaction, overall happiness, and overall quality of life (QOL) (Jeong et al., 2019; Lee and Lee, 2021; Moon et al., 2016). Particularly, these impacts are evident among elementary students in South Korea, who are now part of Generation Alpha. It was found that Korean elementary school students have the lowest life satisfaction levels among OECD countries which is highly affected by the overuse of digital devices (Lee and Lee, 2021) and 37% of South Korean children and adolescents between the age of 10-19 are found to be overdependent on smartphones (Kan, 2022). In response to this problem, the term 'digital wellbeing' has emerged. As digital wellbeing (DW) is a highly subjective notion where the context and one's environment can significantly affect how they interact with technology (Cecchinato et al., 2019), a comprehensive understanding of school-aged Generation Alpha in Korea is crucial in order to address the problem within this specific domain. However, the issues that exist within the Alpha generation's DW can be a complex problem to deal with. Tackling a complex problem is a challenging task as it typically does not have a concrete solution and are considered to exceed one's processing capabilities (Öllinger et al., 2015). To mitigate this, it has been found that tools such as external representation can assist in 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 enable designers to analyse complex systems (da Costa Junior et al., 2019). Considering the complexity of children's DW, it is necessary to examine it through a systems thinking perspective to allow a better understanding of the problem which consequently can result in better adapted design solutions. However, existing literature tends to only focus on a singular aspect or relationship within the issue as they originate from specific fields namely psychology, health, and child studies; hence, they fail to examine the issue as a whole at a systemic level. Therefore, this study conducted a systematic literature review to get a state-of-the-art knowledge on the South Korean Generation Alpha's DW and to get a better understanding of this issue from multiple perspectives. To deliver a better grasp of the system, this study also employed a systems thinking perspective in analyzing and visualizing the causal relationships of these issues to examine potential patterns and relationships among these issues.

## 2 DIGITAL WELLBEING

Digital technologies bring both benefits and harms to people's wellbeing. The benefits include improving work productivity (Monge Roffarello and Russis, 2021) and providing hedonic and eudaimonic experiences, which consequently result in the improvement of wellbeing (Henderson and Knight, 2012; Vanden Abeele, 2021). There are also harms, for instance, phone use is found to interfere with social activities (McDaniel and Drouin, 2019), distract from work and study (Duke and Montag, 2017), lead to procrastination (Schnauber-Stockmann et al., 2018), cause sleep and health problems (Lanaj et al., 2014), and induce negative emotions such as emotional exhaustion and anxiety (Büchi et al., 2019). As a recently emerging concept, DW has various definitions and understandings. Nevertheless, there is a consensus that it requires maintaining a healthy relationship with technology by balancing the benefits and harms (Büchi, 2021; Vanden Abeele, 2021; Yue et al., 2021).

## 3 THE COMPLEX PROBLEM OF DIGITAL WELLBEING

Complex problem is characterized by five attributes; large number of variables, considerable connectivity between the variables, existence of multiple, often conflicting goals, the intransparency of the situation, and the dynamicity of the situation which changes over time (Burmeister, 2009; Dörner et al., 1983; Funke, 2001, 2003, 2012; Fischer et al., 2012; Öllinger et al., 2015). Meanwhile, there are

various variables namely individual, socio-cultural, economic, and political factors influence people's DW directly and indirectly (Vanden Abeele and Nguyen, 2022; Valasek, 2022). Moreover, various studies have determined that there are existing causal chains within DW (Büchi, 2021; Byrd, 2020). Considering that technology is constantly evolving aiming to improve convenience and QOL, its' role in daily life continue to transform and consequently impact DW positively and negatively. However, through the systematic literature review undergone in this study, it was found that the goal states, variables, and variables' connectivity within DW are often not visible to the decision makers. Thus, considering the number of variables, non-linear causal relationships that are intransparent, and the dynamic nature of the issue that exist within DW, it can be considered as a complex problem. A complex problem, sometimes referred as a wicked problem (Rittel and Webber, 1973), is constantly evolving, multifaceted and interconnected. It thus requires the involvement of various stakeholders and a holistic observation to avoid oversimplification. Therefore, framing this issue as a complex problem and approaching it using systems thinking allows designers to adopt a holistic perspective through a specific set of assumptions, premises, and axioms, (Blizzard and Klotz, 2012; Clegg, 2000; Cárdenas et al. 2010; Forlizzi, 2012; Jones, 2014) and has the potential to incorporate differing world views (da Costa Junior et al., 2019; Daellenbach, 2001; Jackson, 2003; Jackson and Keys, 1984).

## 4 METHOD

### 4.1 Systematic literature review

We conducted a systematic literature review on the DW 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 the 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 wellbeing" 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, resulted in 282 from KCI and 50 literature from Google Scholar. However, it is important to note that considering the large amount of literature retrieved through Google Scholar ended up not being relevant to the topic, the keyword search was limited to only the title of the literature. A total 689 papers were initially identified. However, as Generation Alpha would start attending elementary schools in 2016 the earliest, the publication year was further restricted to 2016 onwards. After removing literatures published prior to 2016 and duplicates, the number of articles were reduced to 375. The first screening filtered the articles based on the relevancy of the title which removed 181 literatures 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 that involved participants which did not belong in the range of school-aged generation Alpha were removed, resulting in 44 literatures in total for further analysis.

### 4.2 Thematic analysis

To analyse 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 what kind of topics or purposes the existing literature addresses regarding Children's DW in Korea in recent years (Williams and Moser, 2019). The thematic analysis employed in this study is first done by reading the content of the literature where the important findings were highlighted and transformed into meaning units. These meaning units were then derived into more condensed codes, grouping similar findings together. 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 DW in Korea.

### 4.3 Concept mapping

The findings from the systematic literature review and thematic analysis are then mapped using concept mapping (CM). CM is a visualisation tool used in systems thinking to synthesize and interrelate knowledge, and to promote a shared understanding of the system among stakeholders (Burke et al., 2005; Trochim and Cabrera, 2005). CM 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 (Alafairet et al., 2015) and public health (Leischow et al., 2008; Trochim et al., 2006). CM 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 which would represent the views of various stakeholders. The map thus created would include empirical findings which can be used as a baseline for an initial understanding of the system and future conversations and participatory design activities.

## 5 RESULTS

The thematic analysis described above led to the identification of four key themes: effects of digital interaction towards wellbeing, cause/factors that affect digital interaction, factors of digital wellbeing, and solutions/initiatives to improve digital wellbeing.

Table 1. List of reviewed literature organized by theme

Causes/factors that affect digital wellbeing	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
Effect of digital interaction towards wellbeing	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 wellbeing	An and Kang, 2019; Eoh et al., 2022; Hong, 2021; Kim and Jung, 2021; Nam, 2021; Yang et al., 2021
Solutions/initiatives to improve digital wellbeing	Jo and Bang, 2022; Kim and Kim, 2019; Kim and Jung, 2021; King et al., 2018

### 5.1 Causes/factors that affect digital wellbeing

Causes/factors that affect digital interaction was the most popular theme appearing in 22 articles. Firstly, screen time is found to be a prevalent indicator for 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 aspect which includes 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 economy (Lee et al., 2022), peer relationships (Ju, 2019; Kim and Kang, 2022), and COVID-19 (Lee et al., 2022) were also contributing factors which affect children's interaction with digital devices indirectly, impacting their DW. Parents also influenced children's DW 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), parent's perception towards digital devices (Lee et al., 2022; Nam and Hwang, 2019), parent's attitude/behavior towards 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), parent's habits in using digital devices (Lee and Kim, 2021b; Lim and Jeong, 2022; Son et al., 2021), and parent's mental health (Lee et al., 2022; Oh et al., 2021; Park and Noh, 2019). Additionally, parenting factors are often influenced by the external factors such as economic stress and COVID-19 (Lee et al., 2022), further illustrating how external factors can indirectly affect DW.

### 5.2 Effect of digital interaction towards wellbeing

The effect of digital interaction towards wellbeing was identified in 11 articles. They mainly discussed the negative influence of problematic digital interaction namely digital addiction, digital device overuse, and smartphone dependence on children's lives, which includes 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; 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). Both internal and external behavioral problems and screen time, in general, are associated with social and academic adaptation, which consequently both affect 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, further exacerbating the problem and creating a loop. Furthermore, unhealthy relationships with digital devices can also be reflected in physical health 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 tend to be harmful to overall health as it can lower health-promoting behavior due to low self-regulation abilities (Lee and Lee, 2021). Hence, unhealthy and unregulated use of digital devices affect QOL as a whole, including physical, emotional, social, and academic areas.

### 5.3 Factors of digital wellbeing

Factors of DW discussed in this section refer to the aspects that support positive digital usage and indicate positive DW, which in this study are found in seven studies. The factors discussed in this literature are digital literacy, media literacy and self-regulation. The importance of digital literacy to mitigate DW is directed towards both parents and children (An and Kang, 2019; Kim and Jung, 2021; Nam, 2021; Yang et al., 2021). Digital literacy not only includes the use of technology and devices but also socio-cultural literacy such as access to, understanding, participation, creation, cooperation, and sharing within the digital realm (An and Kang, 2019). It is also important for parents to acquire digital literacy since they have the biggest influence on children's early literacy development and they are generally the ones who control the children's media usage through restrictions and guidance (Yang et al., 2021). Media literacy, the ability to discern contents within media, is vital as there are various harmful contents that exist within media such as fake news (Hong, 2021), age-inappropriate contents (Kim and Jung, 2021), and masked advertisement (An and Kang, 2019). Lastly, self-regulation is emphasized throughout various literature (Eoh et al., 2022; Kim and Jung, 2021; Yang et al., 2021). Although parental control is found to be effective to an extent, self-regulation is essential since parental control is no longer effective as children grow up (Yang et al., 2021). Thus, children are required to be able to control their media usage autonomously by understanding the effects of media and by using the information to benefit them positively, buffering the adverse effects of problematic smartphone usage (Eoh et al., 2022; Kim and Jung, 2021; Yang et al., 2021).

### 5.4 Solutions/initiatives to improve digital wellbeing

Various literature introduced solutions to tackle problems such as addiction and improve DW and assess existing prevention programs. For instance, a Youtube literacy program (Kim and Jung, 2021) using a design thinking method that improved students' media literacy capabilities. A group art therapy targeted children's addiction to smartphones, specifically focusing on the delay of gratification theory, the act of delaying immediate satisfaction of needs for the greater good of the future and enduring the spontaneous frustration of the delay (Kim and Kim, 2019; Mischel, 1974). As a result, it showed effectiveness on increasing the participants' self-control, reducing the level of smartphone addiction (Kim and Kim, 2019). A peer support program with the goal 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. The research by Nam and Hwang (2018) aimed to find out about parents' needs and preferences on intervention to reduce the risk of Internet addiction among children. It found the initiatives developed and deployed by corporations and private firms tend to be less favourable, especially for customers with low digital literacy; thus, firms are recommended to develop strategies to change and improve consumers' perceptions of corporate efforts. Lastly, a review of the existing intervention in Korea found that the model of gaming disorder prevention act is similar to the efforts of addressing 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 centres, counselling services, rehabilitation camps, and public education (King et al., 2018).

## 6 DISCUSSION

After analyzing the relationship between each theme, we found that each theme is related to each other, where they would either target, cause, or affected by other themes. This thus confirms our initial assumption that the issues of children's DW are a complex system where each element is intertwined and involves multiple interdependent causes. Fig. 1 is a CM describing the findings of the systematic literature review on generation alpha's wellbeing in South Korea. Overall, causes/factors that affect wellbeing which include screen-time, internal & external factors, type of content, and parental factors affect how they attain digital literacy, media literacy, and self-regulation. Conversely, the lack of the aforementioned skills leads to improper use of digital media, which in turn results in the negative effects of problematic use such as physical health issues and internal & external behavioral problems and impact children's academic performance and social adaptation. The lack of social and academic adaptation skills threatens school adaptation which consequently negatively impacts their social and academic performance, exacerbating the problem. To mitigate this problem, solutions and initiatives directly target the effects of problematic use or address the underlying causes which are usually done by aiming to achieve the skills within the DW factors. Thus, the relationships between the different themes and elements connected to children's DW are illustrated in this map. An example of an existing causal relationship that can be derived from this map is how depressed parents usually lack control over their children's media use, increasing their screen-time which can lead to addiction and other problems. This, in turn, can further inflict more stress on the parents, worsening their mental health which creates a vicious cycle, further aggravating the problem. Based on the understanding of this causality, a future intervention can address parents' psychological health when developing educational programs to break the vicious cycle and contribute to a successful execution of the program. Therefore, this map is able to visually represent the complex system within children's DW and act as an external representation which can benefit in complex problem solution and decision making. External representation allows stakeholders to preserve cognitive functions in assembling and encoding information (Kirsh, 2010), especially in complex systems. This is because 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). Moreover, how the external representation is formulated can influence what information can be perceived and what processes will be activated (Zhang, 1997). Hence, by having a diagram that include a broad system that encompasses various fields and perspectives, it can encourage the stakeholder to take a holistic approach in their decision-making process.

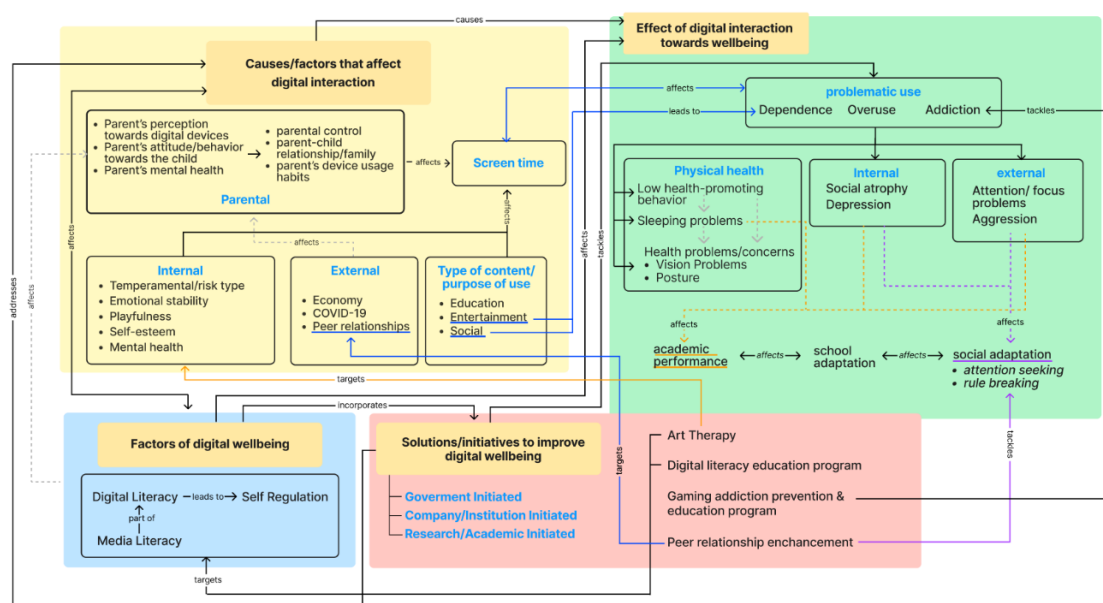


Figure 1. Conceptual diagram of the causal relationships in children's digital wellbeing

## 7 CONCLUSION

This study has explored the current studies conducted on the South Korean Generation Alpha's DW and has discussed and synthesized the findings using CM. However, there are existing limitations in this study, such as the lack of in-depth examination and experimentation when determining the most effective visualization tool to be applied in this study. However, this study is valuable as it contributes to the study of child and family & Human-computer interaction (HCI) studies by contributing state-of-the-art knowledge through the systematic literature findings. Moreover, this study also contributes to the design field as it demonstrates the use of systems thinking visualization tool to approach a complex problem and convey the findings along with the causal relationships that exist among the factors to understand the problem on a systemic level which consequently can improve the outcome of the design solution. This step is essential in complex problem solving as it provides the aid to fill in the knowledge gap, stimulate systems thinking, and reduce the cognitive load which optimizes the solution formulation. Therefore, through the outcome of this study, future research on this topic can have a better gauge of the system and future solution/intervention design can refer to the visualization of the system developed in this study.

## REFERENCES

- Ahn, S., Kang, B., Lee, K. (2017), "Structural Relationships Among Children's Duration of Media Use, Behavior Problems, and School Adjustment", *Korean Journal of Child Studies*, Vol. 38 No. 2, pp.191-204.
- Alafairet, P., Bouras, A., Houghton, H. L., Lavoie, B. J., Lavoie, J. P., Cressman, B., & Modi, S. (2015), "Applying concept mapping to solving in-patient mental health recidivism", *Missouri medicine*, Vol. 112 No. 1, pp. 63–66.
- An, S. and Kang, H. (2019), "Korean children's understanding of social media advergaming: An exploratory study of ad recognition and skeptical attitudes toward advertising", *Journal of Consumer Behaviour*, Vol. 18 No. 5, pp. 387–398. <https://doi.org/10.1002/cb.1778>.
- Blizzard, J. L. and Klotz, L. E. (2012), "A framework for sustainable whole systems design", *Design Studies*, Vol. 33 No. 5, pp. 456–479.
- Büchi, M. (2021), "Digital well-being theory and research", *New Media and Society*. <https://doi.org/10.1177/14614448211056851>
- Büchi, M., Festic, N. and Latzer, M. (2019), "Digital Overuse and Subjective Well-Being in a Digitized Society", *Social Media + Society*, Vol. 5 No. 4. <https://doi.org/10.1177/2056305119886031>
- Burke J.G., O'Campo P., Peak G.L., Gielen A.C., McDonnell K.A., Trochim W.M.K. (2005), "An Introduction to Concept Mapping as a Participatory Public Health Research Method", *Qualitative Health Research*, Vol. 15 No.10, pp.1392-1410. <https://dx.doi.org/10.1177/1049732305278876>
- Burmeister, K. (2009), *Komplexes Problemlösen im Kontext angewandter Eignungsdiagnostik*, Universität Greifswald.
- Cárdenas, C., Sosa, R., Moysen, R., & Martinez, V.G. (2010), "Sustaining sustainable design through systemic thinking", *International Journal of Engineering Education*, Vol. 26 No. 2, pp. 287–292
- Cecchinato, M. E., Rooksby, J., Hiniker, A., Munson, S., Lukoff, K., Ciolfi, L., Thieme, A. and Harrison, D. (2019), "Designing for Digital Wellbeing: A research & practice agenda", *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* [Preprint]. <https://doi.org/10.1145/3290607.3298998>.
- Cho, Y. (2021), "Mediating Effects of Online-Based Leisure Between Parenting Attitudes and Children's Smartphone Dependency", *Korean Journal of Child Studies*, Vol. 42 No. 6, pp. 695-706. 10.5723/kjcs.2021.42.6.6
- Choi, Y., Lee, D. Y., Lee, S., Park, E. J., Yoo, H. J., & Shin, Y. (2021), "Association Between Screen Overuse and Behavioral and Emotional Problems in Elementary School Children". *Journal of child & adolescent psychiatry*, Vol. 32 No. 4, 154–160. <https://doi.org/10.5765/jkacap.210015>
- Clegg, C. W. (2000) "Sociotechnical principles for system design", *Applied Ergonomics*, Vol 31 No. 5, pp. 463–477.
- da Costa Junior, J., Diehl, J. C. and Snelders, D. (2019) "A framework for a systems design approach to complex societal problems", *Design Science*, Vol. 5. <https://dx.doi.org/10.1017/dsj.2018.16>.
- Daellenbach, H. (2001), "Hard OR, soft OR, problem structuring methods, critical systems thinking: a primer", *In Proceedings of the ORSNZ Conference*.
- Dörner, D., Kreuzig, H.W., Reither, F., and Stäudel, T. (1983), *Lohhausen: Vom Umgang mit Unbestimmtheit und Komplexität*, Huber.
- Duke, É. and Montag, C. (2017), "Smartphone addiction and beyond: Initial insights on an emerging research topic and its relationship to internet addiction", *Internet Addiction*, pp. 359–372. [https://doi.org/10.1007/978-3-319-46276-9\\_21](https://doi.org/10.1007/978-3-319-46276-9_21).

- Eoh, Y., Lee, E. and Park, S.H. (2022), "The relationship between children's school adaptation, academic achievement, happiness, and problematic smartphone usage: A multiple informant moderated mediating model", *Applied Research in Quality of Life* [Preprint]. <https://doi.org/10.1007/s11482-022-10080-w>.
- Fischer, A., Greiff, S. and Funke, J. (2012), "The process of solving complex problems", *Journal of Problem Solving*, Vol. 4 No. 1, pp.19-42.
- Forlizzi, J. (2012) "The product service ecology: using a systems approach in design", *In Proceedings of the 2nd conference on Relating Systems Thinking and Design (RSD2)*, pp. 1–27.
- Funke, J. (2001), "Dynamic systems as tools for analysing human judgement", *Thinking and Reasoning*, Vol. 7 No. 1, pp. 69–89. <https://dx.doi.org/10.1080/13546780042000046>.
- Funke, J. (2003), *Problemlösendes Denken*. Kohlhammer.
- Funke, J. (2012), "Complex problem solving", In: N. M. Seel (Ed.), *Encyclopedia of the sciences of learning*, pp. 682–685, Springer.
- Han, H. and Chang, Y. (2020) , "The Effect of Family Leisure and Family Rituals on the Mobile Internet Use and Smartphone Overdependence of Children", *Korean Journal of Family Welfare*, Vol. 25 No.2, pp.141-161.
- Henderson, L. W. and Knight, T. (2012), "Integrating the Hedonic and Eudemonic Perspectives to More Comprehensively Understand Wellbeing and Pathways to Wellbeing", *International Journal of Wellbeing*, Vol. 2, pp. 196-221. <http://dx.doi.org/10.5502/ijw.v2i3.3>
- Hong, N. H. (2021), "Media Literacy and Childhood from the Vulnerable in Media Use to Prosumers of Deviance", *Korean Journal of Communication & Information*, vol. 107, pp. 149-180. <https://dx.doi.org/10.46407/kjci.2021.06.107.149>
- Hong, Y. (2022), "Effects of The Purpose of Smart Device Usage and Executive Function Difficulties on the Types of Changes in Elementary School Children's Smart Device Dependency", *Korean Journal of Child Care and Education Policy*, Vol. 16 No. 1, 1-25.
- Jackson, M. C. (2003), *Systems Thinking: Creative Holism for Managers*. John Wiley & Sons.
- Jackson, M. C. and Keys, P. (1984), "Towards a system of systems methodologies", *Journal of the Operational Research Society*, Vol. 35 No. 6, pp. 473–486.
- Jeong, H., Yim, H. W., Lee, S., Lee, H. K., Potenza, M. N., Jo, S., and Son, H. J. (2019), "Reciprocal relationship between depression and Internet gaming disorder in children: A 12-month follow-up of the iCURE study using cross-lagged path analysis", *Journal of Behavioral Addictions*, Vol. 8 No. 4, pp. 725-732. <https://doi.org/10.1556/2006.8.2019.74>
- Jo, J. and Bang, K.S. (2022), "The effect of peer relationship enhancement programs on the prevention of smartphone addiction among late school-age children in South Korea", *Journal of Pediatric Nursing*, Vol. 63. <https://doi.org/10.1016/j.pedn.2021.09.025>.
- Jones, P. H. (2014), "Systemic Design Principles for Complex Social Systems", In: Metcalf, G. (eds) *Social Systems and Design. Translational Systems Sciences*, vol 1. Springer, Tokyo. [https://doi.org/10.1007/978-4-431-54478-4\\_4](https://doi.org/10.1007/978-4-431-54478-4_4)
- Ju, S. 2019, "The Effects of Personal Factors, Parent Factors, and Peer Factors on Smart-phone Excessive Use by Children in Local Child Center", *The Journal of Humanities and Social science*, Vol. 10 No. 4, pp. 1651-1662. <http://dx.doi.org/10.22143/HSS21.10.4.118>
- Kan, H. W. (2022), *Nearly 1 in 4 Koreans diagnosed with smartphone overdependence*. [Online] The Korea Herald. Available at: <https://www.koreaherald.com/view.php?ud=20220324000637> (Accessed: November 1, 2022).
- Kim, D., and Jahng, K. E. (2021), "The Effect of Children's Negative Automatic Thoughts on Their Problematic Smartphone Use: The Moderating Effect of Weekend Family Rituals", *Korean Journal of Child Studies*, Vol. 42 No. 5, pp.601-614.
- Kim, H. and Jung, H. (2021), "Development and Application of YouTube Literacy Education Program", *Global Creative Leader: Education & Learning*, Vol. 11 No. 2, pp. 31-55. <https://dx.doi.org/10.34226/gcl.2021.11.2.31>
- Kim, H. S. and Choi, J. Y. (2020), "Effects of Internet-Use Controlling Parenting Behaviors and Warm/Rational Parenting Style on Children's and Adolescents' Internet Addiction: Moderation of Child Gender", *Korean Journal of Child Psychotherapy*, Vol. 15 No. 1, pp. 23-36.
- Kim, S. E. and Kang, H. K. (2022), "Influences of playfulness on smartphone dependency among upper grades of Korean elementary schoolers", *International Journal of Environmental Research and Public Health*, Vol. 19 No. 12, p. 7185. <https://doi.org/10.3390/ijerph19127185>.
- Kim, S. and Kim, T. H. (2019), "The Effect of Group Art Therapy on the Delay of Gratification of Children with Smartphone Addiction", *Forum For Youth Culture*, No. 58, pp. 31-60. doi:<http://dx.doi.org/10.17854/ffyc.2019.04.58.31>
- Kim, S. Y., Han, S., Park, E. J., Yoo, H. J., Park, D., Suh, S., & Shin, Y. M. (2020), "The relationship between smartphone overuse and sleep in younger children: a prospective cohort study", *Journal of clinical sleep medicine*, Vol. 16 No. 7, pp. 1133–1139. <https://doi.org/10.5664/jcsm.8446>



- Kim, Y. M. and Park, Y. J. (2021), "The Influence of Happiness Self-esteem on Media Addiction in Elementary School Children: The Mediation Effect of School Adjustment", *Journal of Korea Academia-Industrial Cooperation Society*, Vol. 22 No.7, pp.480-487. doi:<https://doi.org/10.5762/KAIS.2021.22.7.480>
- Kim, Y. H. (2022), "Temperament types at age 3 and smartphone overdependence at age 10", *Frontiers in Psychology*, Vol. 13. <https://doi.org/10.3389/fpsyg.2022.833948>.
- King, D. L., Delfabbro, P. H., Doh, Y. Y., Wu, A. M. S., Kuss, D. J., Pallesen, S., Mentzoni, R., Carragher, N., & Sakuma, H. (2018), "Policy and Prevention Approaches for Disordered and Hazardous Gaming and Internet Use: an International Perspective". *Prevention science : the official journal of the Society for Prevention Research*, Vol. 19 No. 2, pp. 233–249. <https://doi.org/10.1007/s11121-017-0813-1>
- Kirsh, D. (2010), "Thinking with external representations", *AI & society*, Vol. 25, pp.441-454.
- Lanaj, K., Johnson, R.E. and Barnes, C.M. (2014), "Beginning the workday yet already depleted? Consequences of late-night smartphone use and sleep". *Organizational Behavior and Human Decision Processes*, Vol. 124 No. 1, pp.11-23.
- Lee, J. P. and Lee, Y. S. (2021), "Structural equation model of elementary school students' quality of life related to smart devices usage based on precede model", *International Journal of Environmental Research and Public Health*, Vol. 18 No. 8, p. 4301. <https://doi.org/10.3390/ijerph18084301>.
- Lee K. (2020), "Causal Longitudinal Analysis between Media Usage Time Trajectories and School Adaptation Trajectories for Low Grade Elementary School Children", *Journal of Parent Education*, Vol. 12 No. 1, pp. 105-124. 10.36431/JPE.12.1.6.
- Lee, K. and Park, H.-Y. (2022), "Analysis of the Difference on Elementary Students' School Adaptation and Academic Performance by Dependence on Smart Devices", *Journal of the Korea Society of Computer and Information*, Vol. 27 No. 4, pp. 213–221. 10.9708/JKSCI.2022.27.04.213.
- Lee, S. and Kim, M. (2021a), "The Effects of Changes in Media Usage Time on Media Device Addiction and School Adaptation of Children", *Education Review*, no. 47, pp. 212-235. <https://dx.doi.org/10.23119/er.2021..47.212>
- Lee, E. J., and Kim, H. S. (2021b), "Effect of Maternal Factors on Problematic Smartphone Use among Elementary School Children", *International journal of environmental research and public health*, Vol. 18 No. 17. <https://doi.org/10.3390/ijerph18179182>
- Lee, S., Kim, S., Suh, S., Han, H., Jung, J., Yang, S. and Shin, Y. (2022), "Relationship between screen time among children and lower economic status during elementary school closures due to the coronavirus disease 2019 pandemic", *BMC Public Health*, Vol. 22 No. 160. <https://doi.org/10.1186/s12889-022-12559-5>
- Lee, S. and Mun, I. B. (2022), "How does perceived parental rejection influence cyberbullying by children? A serial mediation model of children's depression and smartphone addiction", *The Social Science Journal*. 10.1080/03623319.2022.2070826
- Leischow, S. J., Best, A., Trochim, W. M., Clark, P. I., Gallagher, R. S., Marcus, S. E., and Matthews, E. (2008), "Systems thinking to improve the public's health", *American journal of preventive medicine*, Vol. 35. <https://doi.org/10.1016/j.amepre.2008.05.014>
- Lim, S. I. and Jeong, S. (2022), "The relationship between Korean parents' smartphone addiction and that of their children: The mediating effects of children's depression and social withdrawal", *International Journal of Environmental Research and Public Health*, Vol. 19 No. 9, p. 5593. <https://doi.org/10.3390/ijerph19095593>.
- McDaniel, B.T. and Drouin, M. (2019), "Daily technology interruptions and emotional and relational well-being", *Computers in Human Behavior*, Vol. 99, pp.1-8.
- Mischel, W. (1974), "Processes in delay of gratification", *Advances in experimental social psychology*, Vol. 7, pp. 249-292.
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G. and Prisma Group. (2010), "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement", *International journal of surgery*, Vol. 8 No. 5, pp.336-341.
- Monge Roffarello, A. and De Russis, L. (2021), "Coping with digital wellbeing in a multi-device world", *Proceedings of the 2021 CHI conference on human factors in computing systems*, pp. 1-14.
- Moon, J. H., Kim, K. W. & Moon, N. J. (2016), "Smartphone use is a risk factor for pediatric dry eye disease according to region and age: a case control study", *BMC Ophthalmol*, Vol. 16 No. 188. <https://doi.org/10.1186/s12886-016-0364-4>
- Nam, C. 남창우 (2021). "guknae·oe yu·adong dijiteol gyoyuk donghyanggwa dijiteol gyoyuk baljeon bangan tamsaek 국내·외 유·아동 디지털 교육 동향과 디지털 교육 발전 방안 탐색", *Korea Institute of Child Care and Education*, Vol. 69, pp. 23-29.
- Nam, S. J. and Hwang, H. (2019), "Consumers' needs for public education and corporate participation regarding child internet addiction: based on the risk perception attitude framework", *Journal of Consumer Affairs*, Vol. 53 No. 3, pp.1220-1233.

- Oh, S. C., Kim, Y. K. and Park, J. H. (2020), Latent Profile Analysis of Smart Device Usage Pattern in Children: Smart Device Addiction According to Its Usage Pattern, *Korean Journal of Child Studies*, Vol. 41 No. 1, pp. 47-60. <https://dx.doi.org/10.5723/kjcs.2020.41.1.47>
- Oh, Y., Kim, H. and Joung, Y.S., (2021), “Problematic internet use in children according to maternal depression trajectories: A population-based cohort study with 9-year follow-up”, *Journal of Psychiatric Research*, Vol. 141, pp.364-369.
- Öllinger, M., Hammon, S., von Grundherr, M., & Funke, J. (2015), “Does visualization enhance complex problem solving? The effect of causal mapping on performance in the computer-based microworld Tailorshop”, *Educational Technology Research and Development*, Vol. 63 No. 4, pp. 621–637. <https://doi.org/10.1007/s11423-015-9393-6>
- Park, B., and Noh, J. (2019), “Effects of parenting behaviors and children’s happiness on media device addiction”, *Korean Journal of Child Studies*, Vol. 40 No. 3, pp.87-103.
- Park, M., Jeong, S.H., Huh, K., Park, Y. S., Park, E. and Jang, S. (2022), “Association between smartphone addiction risk, sleep quality, and sleep duration among Korean school-age children: a population-based panel study”, *Sleep Biol Rhythms*, Vol. 20, pp. 371–380. <https://doi.org/10.1007/s41105-022-00377-6>
- Rittel, H.W. and Webber, M.M. (1973), “Dilemmas in a general theory of planning”, *Policy sciences*, Vol. 4 No. 2, pp.155-169.
- Schnauber-Stockmann, A., Meier, A., Reinecke, L. (2018), "Procrastination out of Habit? The Role of Impulsive Versus Reflective Media Selection in Procrastinatory Media Use", *Media Psychology*, Vol. 21 No. 4, pp. 640-668. [10.1080/15213269.2018.1476156](https://doi.org/10.1080/15213269.2018.1476156)
- Song, H. (2022), “Longitudinal Investigations of Autoregressive Cross-Lagged Path Models Among Internet Use, Executive Function Problems, and Maternal Control in Young Korean Children”, *Frontiers in psychiatry*, Vol. 13, p. 846995. <https://doi.org/10.3389/fpsy.2022.846995>
- Son, H. G., Cho, H. J. and Jeong, K. H. (2021), “The effects of Korean parents’ smartphone addiction on Korean children’s smartphone addiction: Moderating effects of children’s gender and age”, *International Journal of Environmental Research and Public Health*, Vol. 18 No. 13, p. 6685.
- Tripto, J., Assaraf, O.B., and Amit, M. (2013), “Mapping What They Know: Concept Maps as an Effective Tool for Assessing Students’ Systems Thinking”, *American Journal of Operations Research*.
- Trochim, W.M.K. and Cabrera, D. (2005), “The complexity of concept mapping for policy analysis”, *Emergence: Complexity & Organization*, Vol. 7 No. 1, pp. 11–22.
- Trochim, W.M., Cabrera, D.A., Milstein, B., Gallagher, R.S. and Leischow, S.J. (2006), “Practical challenges of systems thinking and modeling in public health”, *American journal of public health*, Vol. 96 No. 3, pp.538-546.
- Valasek, C. J. (2022), “Disciplining the Akratic user: Constructing digital (un)wellness”, *Mobile Media and Communication*, Vol. 10 No. 2, pp. 235–250. <https://doi.org/10.1177/20501579211038796>
- vanden Abeele, M. M. P. (2021), “Digital Wellbeing as a Dynamic Construct”, *Communication Theory*, Vol. 31 No. 4, pp. 932–955. <https://doi.org/10.1093/ct/qtaa024>
- vanden Abeele, M. M. P. and Nguyen, M. H. (2022), “Digital well-being in an age of mobile connectivity: An introduction to the Special Issue”, *Mobile Media and Communication*, Vol. 10 No. 2, pp. 174–189. <https://doi.org/10.1177/20501579221080899>
- Verbeek, P. P. (2005), *What Things Do: Philosophical Reflections on Technology, Agency, and Design*, Penn State University Press.
- Williams, M. and Moser, T. (2019), “The art of coding and thematic exploration in qualitative research”, *International Management Review*, Vol. 15 No. 1, pp.45-55.
- Yang, K., Seo, S. H. and Ok, H. J. (2021), "Parents’ perceptions and guidance behavior on media use of children aged 3-9 years old : Focusing on differences in parents’ media education experience", *Journal of Reading Research*, No. 59, pp. 107-136. <https://dx.doi.org/10.17095/JRR.2021.59.3>
- Yoo, K.-H. and Choi, H.-J. (2021), “Effects of parental pressure and autonomy support on academic enthusiasm, in the fourth grade of elementary school: The Mediating Effect of Smartphone Dependence”, *The Korean Journal of Child Education*, Vol. 30 No. 3, pp. 109-129.
- Yoon, J.-Y., Jeong, K.-H. and Cho, H.J. (2021), “The effects of children’s smartphone addiction on sleep duration: The moderating effects of gender and age”, *International Journal of Environmental Research and Public Health*, Vol. 18 No. 11, p. 5943. <https://doi.org/10.3390/ijerph18115943>.
- Yue, A., Pang, N., Torres, F. and Mambra, S. (2021). Developing an Indicator Framework for Digital Wellbeing: Perspectives from Digital Citizenship, *NUSCTIC Working Paper Series No. 1*. Available at: [https://ctic.nus.edu.sg/resources/CTIC-WP01\(2021\).pdf](https://ctic.nus.edu.sg/resources/CTIC-WP01(2021).pdf)
- Zhang, J. (1997), “The nature of external representations in problem solving”, *Cognitive Science*, Vol. 21 No. 2, pp. 179–217. [https://dx.doi.org/10.1207/s15516709cog2102\\_3](https://dx.doi.org/10.1207/s15516709cog2102_3).