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Engagement in educational games and quality of life in early and middle childhood: evidence from a developing country

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Abstract
Serious games (SGs), are gaining prominence as a tool for early education at home as well as in school settings. Given the mixed effects of gamification on various aspects of users' lives, it is pertinent to study its broader effects on a child's pre-school and school years. Given the lack of consensus on a comprehensive measure that encapsulates these effects on an individual's routine functioning, the present study examined whether various engagement states in SGs use influence a relatively broader measure of users' functioning across significant life domains such as Quality of Life (QoL). It is argued that it would serve scholars, teachers, and parents better to understand the broader implications of SGs on children's overall QoL rather than isolated physiological and behavioral effects. Consequently, utilizing structural equation modeling, results from 335 parents of 2–10-year-olds in a developing country showed that cognitive and behavioral engagement in gamified applications appear to influence the child's QoL, but not affective engagement. Results are discussed in terms of the consequences of using game-based technology for a child's development, with far-reaching academic, personal, physical, and social implications not only for the school-going ages, but also for early teenage years. The results are promising in relation to QoL. The findings indicate the role modern technology plays in improving individuals' lives. The findings provide scholars, parents, and creators of SGs important information for their plan of action regarding children's exposure to SGs and making SGs a frequent aspect of the learning experience early in life.

Keywords Children · Engagement states · Gamification · Serious games · Quality of life

INTRODUCTION

Contemporary methods of transferring academic knowledge and professional skills to youngsters have permitted the birth of gamified learning applications or SGs in the digital era (De Freitas & Liarokapis, 2011). They are designed for education, skill acquisition, and attitude and behavior change for children as young as a few months. Studies providing empirical evidence for SGs as effective learning tools (Guillén-Nieto & Aleson-Carbonell, 2012; Johnson et al., 2005), reflect their success in achieving their objectives of knowledge transfer, facilitating behavior change, and developing professional skills.

The effectiveness of SGs for learning is documented in studies reporting a general dominance of interactive simulation-based learning over traditional methods (Vogel et al., 2006). Furthermore, unanticipated benefits of gamification are also reported, such as improved visio-motor coordination, visual attention, and spatial representation (Green & Bavelier, 2006a, 2006b; Nasution et al., 2022; Subrahmanyam & Greenfield, 1994). In addition to their benefits, evidence has also emerged that gaming may inadvertently affect cognitive, physical and socio-emotional health (Gottschalk, 2019), in the form of digital addiction (Emre, 2020; Kesici & Tunç, 2018), and delayed and shortened sleep (Arora et al., 2014; Hale & Guan, 2015). The impact of excessive technology use has even led to addiction recovery applications in order to counter emerging harmful effects (Savic et al., 2013) and reduce depressive symptoms among young cancer patients (Khan et al., 2022).

Therefore, given that modern pedagogical methods have made increasingly greater use of SGs despite inconclusive evidence regarding the effectiveness of computer-assisted teaching (Girard et al., 2013), and potential harmful consequences coupled with learning success (Earp et al., 2014), educational SGs could have important unintended implications for children's lives beyond the learning environment. In the absence of a comprehensive framework that accounts for the wide range of their effects, these effects could be most comprehensively reflected in the users' quality of life (QoL) because studies report the impact of engaging SGs on various aspects of life relevant to QoL. Based on the immersion experience model, where the game aims to keep the user immersed in the game (Dubbels, 2017), the reward action contingency (RAC) in engaging SGs can lead to a transformation in the child's attitudes and behaviors beyond the gaming context by providing an experience representative of future activities (Dubbels, 2017). For example, collaborative SGs impact upon the child's sense of self, coalition-building, and their friendships, while the reward action feedback loop that rewards users' actions during gaming, may

increase learning by helping the user store small chunks of information in their memory for later use (Dubbels, 2017). Others have also reported that engagement in SGs enhances learning – an aspect of QoL (Hamari et al., 2016). For instance, children's involvement in computer-supported environment, where they collaboratively learn and solve complex problems that result improvements in learning and improving QoL (Dindar et al., 2021). Through engaging and immersive elements, frequent videogame players report better hand-eye coordination than non-players, (Griffith et al., 1983). This is likely to facilitate cognitive performance outside the gaming experience. Finally, through their design element of flow (characterized by immediate feedback, self-forgetfulness, and the merging of action with awareness, engaging SGs) are likely to increase the user's sense of control, potential, and empowerment (Dubbels, 2017; Osin, Malyutina, & Kosheleva, 2016). Therefore, it is contended that lack of literature on the implications of SGs for users' QoL beyond learning presents a significant gap that warrants attention. Though QoL can be influenced by many other factors, SGs are capable of creating positive user experiences when they are well-designed and managed (especially when there are concerns about experience-based learning, motivation and assessment).

The primary contribution of the present study is from the psychological approach (Boyle et al., 2011), towards understanding the impact of children's cognitive, behavioral and psychological engagement in SGs on their QoL among the less studied 2-10 year-old, nursery- and- school-going cohort. It is contended that this partly Generation Z and partly Generation Alpha cohort represent the first generation exposed to gamified applications since early childhood, therefore being highly vulnerable to unanticipated impact of digital technologies owing to their developmental and socialization stages. Additionally, the present study contributes to the literature on QoL by showing how routine-use technology intended for learning may have broader implications for a child's QoL. If unrecognized, this vulnerability and susceptibility to influence from SGs presents developmental implications for a child's formative years with potential

impact well into early teen years. Furthermore, the present study may help parents, SG scholars, educators, parents, and creators to realize the potentials on how the modern technologies hold in improving lives in early childhood and beyond.

Literature review

Psychological engagement with digital applications (apps)

The gamification industry, which deals with incorporating game-design elements in traditionally non-game contexts (Zahedi et al., 2021), is estimated to reach $37 billion (US) by 2027. The industry draws its success from its popularity, attributable to the successful incorporation of immersive design elements which are psychologically engaging for the users (Abbasi, Asif, et al., 2020). User engagement is likely to occur in SGs with specific design elements (Maheu-Cadotte et al., 2018), that are psychologically appealing to the user, such as being challenging and interactive, thereby meeting autonomy, relatedness, and competence needs (Abbasi, Hassan, et al., 2021; Behl et al., 2022; Mills et al., 2018). The intrinsic motivation arising from psychological need fulfilment during gaming (DomíNguez et al., 2013; Eisingerich et al., 2019; Eppmann et al., 2018; Hamari, 2017; Hamari & Koivisto, 2015; Harwood & Garry, 2015; Helmefalk & Marcusson, 2019), enables users' immersion in the learning application (McMahan, 2003; Shernoff et al., 2003), and their persistence in completing self-selected goals that stem from the learner's interest and concentrated attention (Alt, 2021).

Engaging SGs relieve children of the traditional and alienating methods of instruction through their innovative designs. They do this by incorporating various game design elements for added sensory appeal and psychological immersion not inherent in traditional, lecture-based pedagogy, such as competition, reward points, badges, levels, leader boards, digital gifts, feedback, story-telling, use of color and music and/or background tones (Sailer et al., 2017). These engaging elements satisfy users' competence,

autonomy, and relatedness needs (Sailer et al., 2017), leading to better learning (Poondej & Lerdpornkulrat, 2016). Engaging features of SGs also add an affective element to an otherwise strictly cognitive exercise, explaining the success and popularity of a human-computer interface for pedagogical objectives (Przybylski et al., 2010). The game interface provides a route for needs satisfaction, in line with self-determination theory. According to The Motivational Model for Video Game Engagement, video games (VGs) satisfy related needs by providing opportunities for interaction—competence needs through challenging goals, and autonomy needs through user choice in terms of strategies and opportunities for action (Przybylski et al., 2010). VGs also incorporate specific elements in a gamified learning environment (Abou-Shouk & Soliman, 2021; Ding et al., 2017), facilitating customer retention for its creators (Feng et al., 2020).

From a psychological viewpoint, engagement with software-based applications refers to the user's combined cognitive, affective and behavioural states triggered due to a two-way interaction (Abbasi, Ting, Hlavacs, Costa, et al., 2019, p. 45). A key aspect of engagement with software applications is interactivity, which results in a state of involvement with the software application in order to satisfy the user's hedonic, utilitarian, as well as social needs (Huang et al., 2017). Engagement essentially involves the degree to which the developed software immerses its user (Bitrián et al., 2021; Li et al., 2014), which is what software companies essentially aim for. Educational applications and technological gadgets essentially aim to incorporate such features that encourage children to think (Couse & Chen, 2010). Furthermore, engagement in gamified applications and their narrative is more likely to lead to achieving learning goals and behavior change (Abbasi, Ting, Hlavacs, Costa, et al., 2019; Brigham, 2015; Brodie et al., 2011; Buckley & Doyle, 2016; Deci & Ryan, 2008, 2012; Deterding et al., 2011). For educational SGs, it is imperative to note that modern theories of pedagogy suggest that learning is most effective when it is active, experiential, situated, problem-based, and provides immediate feedback (Boyle et al.,

2011). SGs appear to offer activities that include these features by enabling the learner to compete, explore, and use innovative thinking, and in doing so, enable the learner to acquire skills they can use beyond the gaming interface (Fitzgerald & Ratcliffe, 2020).

Outcomes of serious game use

In the study context, it is argued that serious games will impact QoL positively. There are a number of studies that have shown this relationship: promoting the treatment of serious mental illness (Fitzgerald & Ratcliffe, 2020), arm rehabilitation (Jonsdottir et al., 2018), reconstructing a functional environment (Ghorbani et al., 2022), health outcomes for children with chronic diseases (Holtz et al., 2018) and etc. Several studies have reported that SGs have positive outcomes for learning and other aspects of life. A meta-analysis on SGs and QoL, for example, have an effect on mental health (Fleming et al., 2017) and personalized health (McCallum, 2012), they improve students' learning and affect (Lamb et al., 2018), and have implications for overall health and wellbeing among older adults (Nguyen et al., 2017), including mood regulation in patients with major depressive disorder (Lin et al., 2020; Ma & Zheng, 2011). Others have suggested that positive outcomes associated with SG use expand beyond individual-level outcomes, as they may play a role in developing human capital (Earp et al., 2014). Owing to their proven effectiveness for various life domains, it is contended that SGs may offer an interactive experience through their unique attributes that may influence aspects of life that improve users' overall QoL. For example, *Taleemabad,* a widely used learning app in Pakistan (for children—from nursery age to Grade 5), offers education in mathematical skills, Urdu and English language, science, and Quranic recitation, through lessons, interactive tests, and story-telling. Since educational SGs offer content that helps expressive communication, mathematical, and language skills that may be of use beyond the game and educational environment, they may also offer wider implications for QoL indicators such as opportunities

for learning and creativity, for example, the technology use that are linked to improving conflict resolution and managing frustrations and disagreements (Bavelier et al., 2010), these educational applications, through their non-traditional teaching methods, are likely to offer similar outcomes in life adjustments such as school readiness and conflict resolution.

While the aforementioned literature highlights the benefits of SGs for various life domains, others have identified the dual consequences of applying gamification for learning (Andrade et al., 2016). Non-cognitive skills aside, some scholars have questioned the effectiveness of computer-assisted learning. For example, Angrist and Lavy (2002) reported negative cognitive effects of a computer-aided instruction program in relation to 4th-grade students' mathematics scores. Other research has shown that the literacy skills gained from computer-aided programs for 3rd to 6th graders may not transform into reading ability and language acquisition (Rouse & Krueger, 2004). Furthermore, engagement in gamified apps displace routine activities that offer social interaction such as time with family and friends, and influence sleep patterns (Fiorini, 2010), suggesting that engagement in game-based applications may have some adverse consequences.

Given both positive and negative outcomes of SGs use, the immersive and psychologically engaged experience in engaged SG use may lead to an overall higher QoL if the advantages of SGs outweigh their disadvantages. Vice versa, a negative association between engagement in SGs and QoL may indicate the disadvantages associated with SGs use outweigh their advantages, with developmental implications for early and late teenage years.

Psychological engagement with serious games and quality of life

QoL is defined as "an individual's perception of his/her position in life pertaining to one's culture and value systems in which s/he lives, and in relation to his/her goals, expectations, standards and concerns"

(Skevington et al., 2021; WHOQoL, 1993), and is an indicator of wellbeing beyond traditional indicators of health, related to personal perception rather than an objective and measurable entity (Dokumacı, 2019). This primarily subjective way of gauging an individual's well-being refers to satisfaction with life-domains principally considered important (e.g., physical, psychosocial, and emotional aspects of an individual's life; Bowling & Windsor, 2001). With regard to the various subjective measures of QoL (proposed using different measures over time), some are domain-specific, while others are multidimensional scales. For example, the QoL has been operationalized as satisfaction with life (Diener et al., 1985), as a QoL inventory (Frisch et al., 1992), as an overall QoL scale (Burckhardt et al., 2003), and as QoL enjoyment and satisfaction (Endicott et al., 1993). The World Health Organization QoL Scale (WHOQOL-BREF) assesses physical and psychological health, quality of social relationships, and features of an individual's environment (WHO, 1996).

QoL gives insight into an individual's satisfaction with life domains such as creativity, quality of work, leisure time, and social interactions (Katschnig, 2006). Assessing the impact of SG engagement on the QoL of school children (aged 2-10 years), is imperative for two reasons. First, frequent SG use in pedagogy entails investigating whether the technology-based tool is harmful beyond the teaching context. If so, schools, parents, and SG developers may need to re-evaluate this approach in early school learning. Secondly, adverse effects have been associated with the use of screen-based technologies, (e.g., reduced self-esteem and poor sleep from varying patterns of social media use; Steinsbekk et al., 2021; Tandon et al., 2020), depression, obesity, and cardiovascular disease from excessive screen time (Lissak, 2018; Thompson, 2022), and neglect of self-care needs such as proper sleep and meal-taking (e.g., proper sleep and meal-taking, among problem gamers; Shi et al., 2019).

Despite their harmful consequences, any potentially positive outcomes on QoL would validate the

significance of technology in teaching and beyond. Owing to a deeper involvement with SGs resulting from immersive design features of interactivity and immersion in computer-assisted learning lacking in traditional pedagogy, (Huang et al., 2019; Tisza & Markopoulos, 2021), engagement in SGs is likely to influence behaviors outside the game-based learning context. This argument is in line with studies suggesting that SGs enable a deeper level of learning, and result in positive short-term benefits such as well-being. SGs for health have been known to improve QoL among clinical samples (Cha et al., 2019), because users continue utilizing skills acquired from gaming beyond the gaming context (Nicholson, 2015). Likewise, the subjective experiences of absorption, interactivity, and conscious attention associated with cognitive, behavioral and affective engagement with SGs, are likely to increase the chances that the learning experience will be internalized, leading to tacit transfer of the learning experience to other domains of social life relevant to QoL. For example, playful competition in game-based learning is known to foster collaborative learning through positive interdependence (Romero, Usart, Ott, & Earp, 2012), that may contribute to quality of friendships. Additionally, for young children, SGs increase motivation, autonomy, and self-esteem (Papanastasiou, Drigas, & Skianis, 2017), that may facilitate children's views of themselves. In a learning context, engagement enhances skill acquisition and learning (Appleton et al., 2006; Chen & Lee, 2018), and engagement in SGs may even be essential for effective learning (Dele-Ajayi et al., 2016; Yu et al., 2021). Given that these effects of SGs (learning, friendships, self-regard, and creativity etc.), are indicators of QoL, hypotheses were formulated to explore the impact engagement in educational SGs may have on a child's QoL in general. More specifically it was hypothesized that:

H1. Cognitive engagement with the gamified applications influences children's QoL.

H2. Affective engagement with the gamified application influences children's QoL.

H3. Behavioral engagement with the gamified applications influences children's QoL.

Insert Figure 1 about here

3. Methodology

3.1 Sample, survey design, and procedure

Data were collected from five major cities of Pakistan (Islamabad, Karachi, Lahore, Rawalpindi, and Peshawar). Owing to their demographic and socio-economic factors (indicating better access to SGs through tablets, smartphones, laptops etc.), these cities were likely to have more SG users in the intended age group than other cities and towns in the country. While selecting the participants for the present study, purposive sampling was applied because the study had specific assessment criteria (Etikan et al., 2016) for potential participants (e.g., parents should have children aged 2-10 years old, their children should be frequently involved in playing SGs including games such as *Taleemabad, PBS Kids Game, Dragon Box,* games on bespoke SG websites such as *ABCya.com, Funbrain.com,* and *Arcademics.com*, as well as more general preschool learning games, and matching game). Prior to data collection, the purpose of the survey was explained to parents (i.e., how children's cognitive, affective, and behavioral engagement when playing SGs can positively impact on their QoL)."

The sample size was calculated utilizing G*power version 3.0 using the following options: test family (*F* tests); a statistical test (linear multiple regression: fixed model, R^2 deviation from zero); effect size f^2 (0.15); error probability (0.05); power (0.95); and number of preceptors (n=3). The recommended sample size was 119. However, in order to increase the study's generalizability and external validity, data were collected from a much greater number of participants (i.e., 335 valid responses).

The survey comprised two sections. Section 1 consisted of demographic information (e.g., child's age, parent and child gender, city of residence, SG playing frequency, devices and applications used). Section 2 examined game engagement dimensions comprising behavioral, affective, and cognitive

engagement. This section also examined QoL assessed via parent-reports of their overall satisfaction with important life domains of their non-clinical, school-going child. Notwithstanding disease and disability, parental reports are likely to give insight into their child's general well-being in the form of their performance in important life domains, which may have implications for their development (Lindner et al., 2016). Table 1 provides an overview of participant demographics.

Insert Table 1 about here

3.2 Measures

Children's QoL was assessed using the Brunnsviken Brief QoL Inventory (BBQ; (Lindner et al., 2016). The scale reflects an individual's overall satisfaction in six living areas, including recreation, philosophy of life, creativity, learning, self-regard, and friendship, assessed on 12 items (e.g., "*My child's leisure time is important for his/her quality of life."*), and rated on a five-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). A higher score indicates greater QoL. See Appendix A for the detailed survey items used in the present study.

3.3 Data analysis

Data were analyzed using partial least squares structural equation modeling (PLS-SEM). This is the recommended technique for testing new relationships, relatively complex models, and formative and reflective constructs (Hair et al., 2020; Hair et al., 2011). The two-step analysis process comprises measurement model assessment, followed by a structural model assessment.

4. Results

4.1 Assessment of the measurement model

As shown in Figure 1, the study proposes a model comprising the engagement states. For instance,

cognitive engagement comprises user absorption and conscious attention towards the game; affective engagement comprises user dedication and enthusiasm; and behavioral engagement comprises social connection and interaction (Abbasi, Nisar, et al., 2020; Abbasi et al., 2017; Abbasi, Ting, Hlavacs, Costa, et al., 2019; Abbasi, Ting, Hlavacs, Fayyaz, et al., 2019). QoL is quantified by leisure time, views about life, creativity, learning, view of self, and friends and friendship using the scale by Lindner et al., (2016).

4.2 Reflective model assessment

To assess the reflective constructs, reliability and validity were established. The reliability of measurement models was interpreted based on outer loading, Cronbach's alpha, and composite reliability (threshold value 0.7). Convergent validity was established through average variance extracted (AVE) (threshold 0.5). Finally, the Heterotrait-Monotrait Ratio (HTMT) ratio of correlation was used to establish discriminant validity (threshold value 0.85) (Hair et al., 2020; Hair et al., 2019; Hult et al., 2018). All outer loadings, Cronbach's alpha, CR, and AVE values exceeded their respective threshold points confirming the model's convergent validity (Table 2).

Heterotrait-Monotrait (HTMT) is a novel method for quantifying discriminant validity (Henseler et al., 2015). The HTMT ratio of correlation for all constructs must be less than the threshold value of 0.90 for a similar concept (e.g., loyalty, cognitive satisfaction, and affective satisfaction). On the other hand, if the variables are distinct from each other, the threshold should be below 0.85. Table 3 displays the HTMT values showing less than a threshold of 0.85, establishing discriminant validity.

Insert Table 2 and 3 here

4.3 Assessment of second-order formative constructs

VG engagement is a second-order formative construct comprising cognitive, behavioral, and affective

engagement (Abbasi, Nisar, et al., 2020). To creating second-order formative constructs, Becker et al. (2012) propose a two-stage process. The first stage involves assessing latent-variable outcomes of the first-order reflective constructs. Secondly, as an indicator for modeling second-order formative constructs, first-order reflective constructs scores were utilized. To assess the validity of second-order formative constructs, the VIF (variance inflation factor) was evaluated, which was used to check for multicollinearity in the formative indicators. Multicollinearity is indicated if the VIF value exceeds the threshold of 5. The measurement weight of indicator, loading and significance level were tracked to assess reliability and validity (Hair et al., 2017; Hair et al., 2020; Hair et al., 2019). Table 4 shows indicator weights and VIF for the second-order formative framework, showing that the second-order formative constructs were reliable and valid.

Insert Table 4 here

4.4 Assessment of the structural model

After the assessment of the measurement model, the second step is the structural model. Bootstrapping was performed with a 5000 subsample (Hair et al., 2016; Hair et al., 2019) from the usable sample size of 335. Table 5 and Figure 2 show the path coefficient, f^2, t-value and p-values for the corresponding paths. Results showed that QoL was positively associated with cognitive engagement (β = 0.540, $t = 7.661$, $p < 0.001$) and behavioral engagement ($\beta = 0.274$, $t = 3.141$, $p < 0.005$), confirming H1 and H3. However, no support was found for H2 because QoL showed no significant relationship with affective engagement ($\beta = -0.040$, $t = 0.576$, $p > 0.005$).

Insert Table 5 and Figure 2 here

5. Discussion

The increasing use of gamified software for learning objectives, at virtually little or no cost (Flunger

et al., 2019), as well as the literature being generally inconclusive with respect to their effects, warrants scholarly attention to its potential consequences beyond the learning context. The present study addressed this gap by exploring the link between engagement in SGs and QoL. The results showed that cognitive and behavioral engagement in educational SGs positively impacted schoolchildren's QoL and that educational SGs may result in long-term behavioral change (Buckley & Doyle, 2016). Considering the developmental needs of this age group, SGs appear to play a positive role in influencing their learning, skills, relationship quality, and other aspects of life encapsulated by the QoL construct and therefore has significant implications. This shows that by being psychologically involved in the gaming experience of educational games, not only do children acquire essential literacy, numeracy, and conceptual skills, but also benefit in unintended ways. This implies that various elements of the gaming interface such as an interactive experience, storytelling, and rewards upon task completion offer learning opportunities that influence their life beyond the game.

Perhaps this impact on QoL comes from a learning interface less exhausting and less boring than traditional learning methods, the confidence gained from skills acquired from these apps, or a combination of these and other reasons. From a psychological viewpoint, this shows that contemporary technology-based pedagogical methods may offer larger, unintended benefits in early childhood as well as potential implications into the crucial teenage years. The present study confirms that the positive influence of enhanced engagement and motivation from SGs use (Zainuddin et al., 2020), one of the key reasons behind the widespread SG use in learning contexts for early and middle childhood, extends beyond the learning context, with implications for the child's growth and well-being.

Although there was no reason to distinguish between affective, cognitive, and behavioral engagement in terms of their implications for QoL, there is one plausible reason for the different results. The lack of

a relationship between affective engagement and QoL may result from the frustration ensuing from competitive elements within the gaming experience. The extant literature has shown that negative emotions such as frustration are non-conducive to learning (Meyer & Turner, 2006), and in the context of the present study, they may inhibit the transfer of learned skills to real-life problem solving, critical thinking, and social intelligence. Although not statistically significant, the negative regression coefficient for affective commitment and QoL was somewhat surprising, given that cognitive and behavioral engagement show a statistically significant, *positive* relation with QoL. Perhaps the negative (albeit, insignificant) results between affective engagement and QoL may signal some unidentified effects of SG use. These results signal some connection with research highlighting the harmful effects of technology use.

Such an explanation of these different results is speculative. In order to get more conclusive results, future research should consider more detailed analyses and methodologies. For example, future research should adopt experimental methods to compare the effects of affectively, cognitively, and behaviorally engaging elements of educational SGs on QoL. Furthermore, future work should consider the specific aspects of QoL and its related constructs such as life satisfaction and relationship building which are particularly influenced by these elements of the gaming interface. This may offer future SG developers the basis for the inclusion/exclusion of particular elements from the gaming interface used for pedagogy as well as for designing SGs customized for specific results.

In terms of practical implications, although the present study does not offer definitive directions for SG use, it offers initial insight into the unintended positive (and in terms of affective engagement, potentially negative) effects of SG use and their design for educationists, parents, and SG developers. It shows that the very elements of SGs intended to engage youngsters affectively, might be potentially harmful, and that cognitively engaging elements such as critical thinking, comparisons, and analogies, as

well as behaviorally engaging elements, may benefit children. Accordingly, SGs can be designed for educational purposes, motivation, and improving wellbeing (Hosťovecký et al., 2020; Zainuddin et al., 2020). The present study also gives initial insight into the potential implications of other SGs for QoL among adults. For example, perhaps engagement with a gamified application shapes an individual's daily routine (e.g., regularity of exercise or picking up a healthy eating habit), ultimately affecting adults' QoL. With this process in mind, managers could focus on incorporating such engaging elements into gamified platforms that can encourage users to change their behavior, creating a shift in their behavior patterns, with a positive influence on their QoL.

5.1 Study Limitations

The present study primarily focused on investigating if children's cognitive, behavioral and affective engagement in SGs influenced their QoL and did not investigate many other possible antecedents that may contribute positively or negatively to their QoL (e.g., parental education, parental income, food insecurity, poor schooling, peer friendship, extramural activities, etc.). Future studies can replicate our study model to study the role of other gamified apps (e.g., apps designed to reduce depressive symptoms, health, and fitness apps etc.) in promoting QoL among other age groups. Furthermore, studies could look for dispositional moderators such as personality to examine the effect between engagement states and QoL. Since the study context was limited to children, future research may be conducted on teenagers, and the younger generations (e.g., Z and Y) to compare and validate the study findings. Furthermore, future studies could compare the relative improvement brought about by gamified apps for improvement in QoL measured through alternate measures. These include health-related QoL, happiness measures, and satisfaction with life etc. Additionally, studies could compare the relative contribution of various gamified apps in improving these health and happiness related QoL measures in developing versus

developed countries. Perhaps these studies can establish the significance of gamified apps in improving QoL in an increasingly volatile world exposed to various threats to QoL.

Another limitation of the study is the possible bias arising from parent-reported QoL ratings of their own children. Parent-reports are common for assessments relating to children's technology use and their effects on subjective constructs such as well-being when young because children may be unable to reliably respond to construct items at times (Abbasi, Shamim, et al., 2021). Nonetheless, parent-reports may raise concerns. This may serve as a starting point for future studies to devise methods for reliably measuring self-reports of QoL among young children. A cross-sectional design was utilized to determine children's QoL in the context of playing SGs and did not examine temporal factors (Wang & Cheng, 2020) while establishing the relationships between children's engagement states (comprising cognitive, affective, and behavioral) in SGs and their QoL. The study attempted to explore the relationships between children's engagement states (comprising cognitive, affective, and behavioral) in SGs and their QoL. Data were collected from exposed users (i.e., children who used SGs) via their parents, utilizing observer reports. However, longitudinal studies are needed to establish the casual links between children's engagement states in SGs and their relationship with QoL. Furthermore, it should be acknowledged that game playing may itself be common in households where parents already have a higher QoL (through access to and knowledge of technologies such as SGs), or where parents are more focused on providing environments and experiences that contribute to QoL. However, distinguishing QoL resulting from SG use, from QoL resulting from these other factors was beyond the scope of the present study. Other limitations include the purposive sampling of participants and the possibility of experimenter bias.

Compliance with Ethical Standards

Conflict of Interest: On behalf of all co-authors, the corresponding author declares that there is no conflict of interest.

Availability of data and material: The dataset used in the present study will be provided by the corresponding author on reasonable request.

Ethical Approval: All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent: Informed consent was obtained from parents on behalf of children as parents need to report about their children's engagement states in SGs and QoL.

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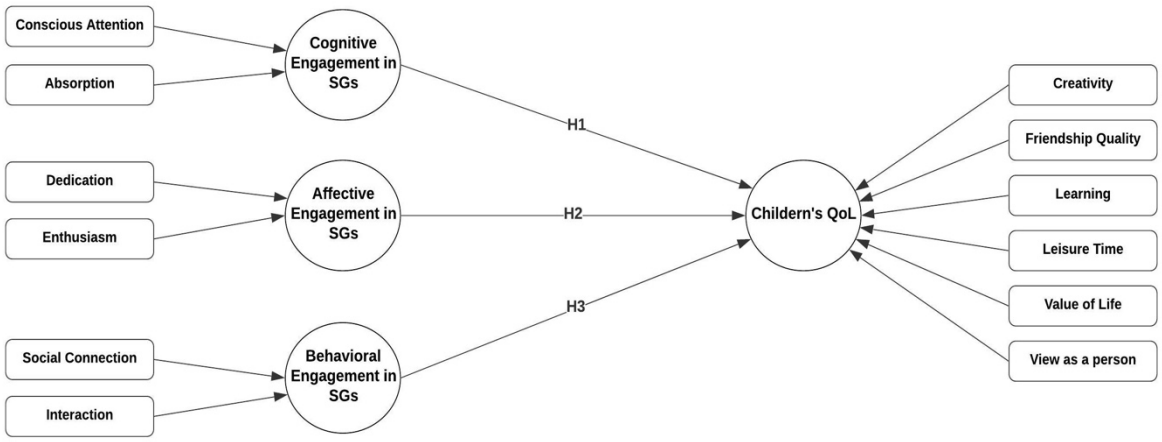

Figure 1. Study Model

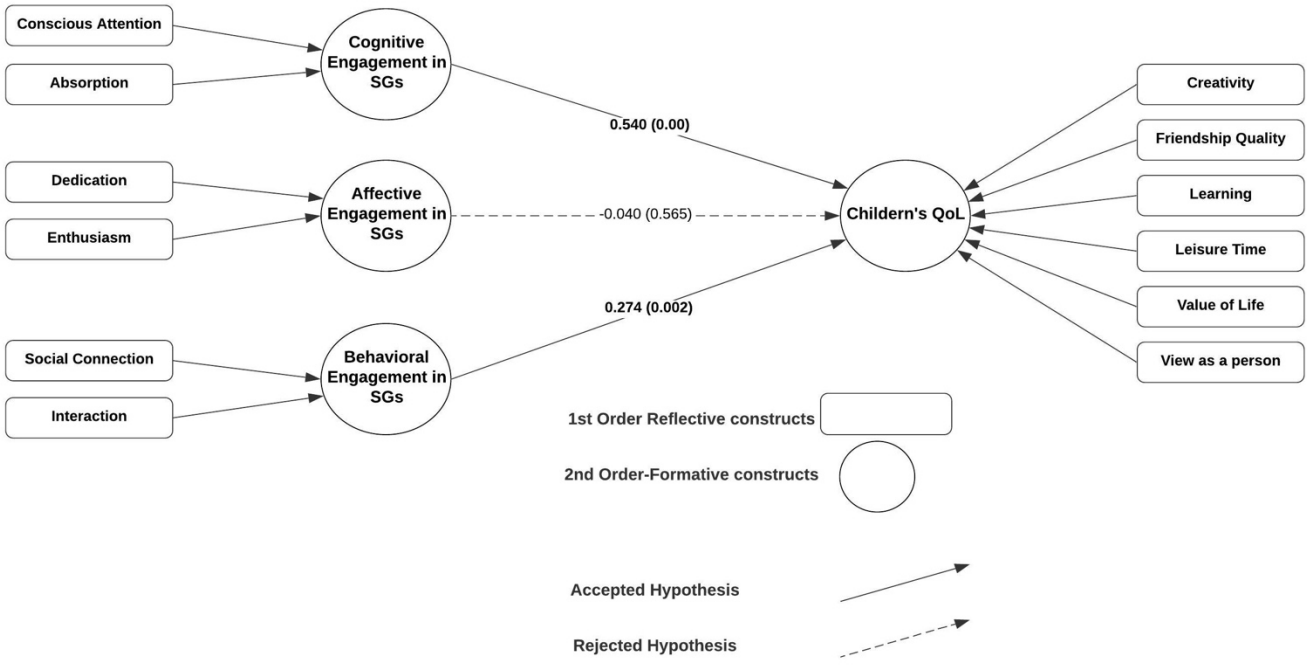

Figure 2. A conceptual model with results

Table 1. Overview of Participants' Demographics

Demographic variable		Frequency	Percent
Gender	Male	196	58.5
	Female	139	41.5
Age of parent	23-29	94	28.1
	30-36	138	41.2
	37-44	103	30.7
Child's gender	Boy	242	72.2
	Girl	93	27.8
Age of child	2-4	111	33.1
	5-7	126	37.6
	8-10	98	29.3
City of residence	Islamabad	75	22.39
	Rawalpindi	60	17.92
	Karachi	85	25.34
	Lahore	65	19.42
	Peshawar	50	14.93
Serious game playing			
Frequency	Daily	110	32.8
	Every Now and Then	78	23.3
	Frequently	147	43.9
Gadgets	Smartphone	165	49.3
	Computer/Laptop	47	14.0
	Tablet/iPad	104	31.0
	Gaming Console	19	5.7
Apps	PBS Kids Game	26	7.8
	Dragon Box	46	13.7
	ABCya.com	14	4.2
	Funbrain.com	47	14.0
	Arcademics.com	7	2.1
	Kids GK	27	8.1
	Taleemabad	46	13.7
	Kids preschool learning games	58	17.3
	Kids matching game	64	19.1
	Total	335	100.0

Table 2. Results of the assessment of the measurement model reflective constructs

Scale	Items	Loading	Cronbach Alpha	CR	AVE
Conscious Attention	Item 1	0.866	0.915	0.934	0.702
	Item 2	0.893			
	Item 3	0.888			
	Item 4	0.796			
	Item 5	0.812			
	Item 6	0.763			
Absorption	Item 1	0.774	0.887	0.915	0.684
	Item 2	0.820			
	Item 3	0.800			
	Item 4	0.875			
	Item 5	0.862			
Dedication	Item 1	0.907	0.905	0.929	0.725
	Item 2	0.842			
	Item 3	0.881			
	Item 4	0.833			
	Item 5	0.790			
Enthusiasm	Item 1	0.808	0.875	0.908	0.667
	Item 2	0.769			
	Item 3	0.890			
	Item 4	0.892			
	Item 5	0.708			
Social Connection	Item 1	0.893	0.855	0.91	0.771
	Item 2	0.888			
	Item 3	0.851			
Interaction	Item 1	0.877	0.93	0.947	0.78
	Item 2	0.892			
	Item 3	0.899			
	Item 4	0.907			
	Item 5	0.839			
Creativity	Item 1	0.940	0.802	0.908	0.832
	Item 2	0.883			
Friendship Quality	Item 1	0.909	0.847	0.927	0.865
	Item 2	0.950			
Learning	Item 1	0.946	0.843	0.926	0.862
	Item 2	0.911			
Leisure Time	Item 1	0.875	0.788	0.902	0.821

	Item 2	0.937			
Value of Life	Item 1	0.918	0.85	0.93	0.869
	Item 2	0.946			
View as a person	Item 1	0.935	0.823	0.918	0.849
	Item 2	0.908			

Table 3. Discriminant validity (HTMT) analysis

	Ab	**CAtt**	**Creat**	**Ded**	**Enth**	**Frien**	**Interac**	**Lear**	**LT**	**SC**	**VasP**	**VL**
Ab												
CAtt	0.804											
Creat	0.541	0.667										
Ded	0.521	0.63	0.419									
Enth	0.650	0.67	0.421	0.84								
Frien	0.384	0.561	0.629	0.496	0.442							
Interac	0.517	0.702	0.628	0.787	0.629	0.479						
Lear	0.483	0.538	0.605	0.471	0.436	0.832	0.413					
LT	0.608	0.705	0.718	0.377	0.501	0.537	0.487	0.65				
SC	0.595	0.617	0.447	0.603	0.539	0.446	0.617	0.441	0.575			
VasP	0.445	0.417	0.692	0.362	0.401	0.561	0.439	0.589	0.532	0.439		
VL	0.578	0.442	0.714	0.355	0.32	0.411	0.406	0.513	0.485	0.322	0.493	

Note: *Dedication, Enth: Enthusiasm, Frien: Friendship quality, Interac: Interaction, Lear: Learning, LT: Leisure time, SC: Social Connection, VasP: View as a person, VL: Value of life.*

Table 4. Validity tests second-order constructs

Constructs	Items	Scale Type	Weights	Loadings	Significance of weights	Significance of loadings	VIF
Behavioral engagement	Interaction	Formative	0.651	0.923	0.00	0.00	1.501
	Social connection		0.471	0.847	0.00	0.00	1.501
Affective engagement	Dedication	Formative	0.399	0.897	0.007	0.00	2.272
	Enthusiasm		0.666	0.964	0.00	0.00	2.272
Cognitive engagement	Absorption	Formative	0.258	0.84	0.012	0.00	2.147
	Conscious Attention		0.796	0.984	0.00	0.00	2.147
QoL	Creativity	Formative	0.384	0.867	0.00	0.00	2.372
	Friendship		0.268	0.71	0.002	0.00	2.174
	Learning		-0.018	0.681	0.846	0.00	2.406
	Leisure time		0.483	0.858	0.00	0.00	1.712
	Value of life		0.124	0.617	0.096	0.00	1.593
	View as a person		-0.003	0.591	0.972	0.00	1.629

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 5. Results of hypothesis testing

Hypothesis Testing	Path coefficient	f^2	*t*-value	p-value	Result
Cognitive engagement in SGs→ QoL	0.540	0.287	7.661	**0.000*** **	**SUPPORTED**
Affective engagement in SGs → QoL	-0.040	0.002	0.576	0.565	INSIGNIFICANT
Behavioral engagement in SGs → QoL	0.274	0.065	3.141	**0.002****	**SUPPORTED**

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Appendix A: Observer Report for Assessing Children's Engagement in Serious Games and their QoL

Item#	*Statements*
(1)	***Conscious Attention***
1	My child likes to learn more about the SG.
2	My child notices information related to the SG.
3	My child pays a lot of attention to anything related to the SG.
4	My child keeps up with things related to the SG.
5	Anything related to the SG grabs the attention of my child.
6	My child can concentrate on the SG for a long time.
(2)	***Absorption***
1	My child forgets everything else while playing the SG.
2	Time flies for my child while playing the SG.
3	My child gets carried away while playing the SG.
4	My child gets immersed in playing the SG.
5	My child is happy while intensely playing the SG.
(3)	***Dedication***
1	The SG inspires my child.
2	My child is enthusiastic about playing the SG.
3	My child feels proud while playing the SG.
4	My child finds the SG as meaningful and purposeful.
5	My child is excited when playing the SG game.
(4)	***Enthusiasm***
1	My child spends a lot of his/her discretionary time playing the SG.
2	My child is heavily into playing the SG.
3	My child is passionate about playing the SG.
4	My child enjoys spending time playing the SG.
5	My child tries to fit the SG playing time into his/her schedule/activities.
(5)	***Social Connection***
1	My child loves playing the SG with his/her friends.
2	My child enjoys playing the SG more when he/she is with others.
3	Playing the SG is more fun for my child when other people around him/her play it too.
(6)	***Interaction***
1	My child likes to get involved in the discussions about playing the SG game.
2	My child enjoys playing the SG with other like-minded game players.
3	My child likes to actively participate in the discussions about the SG.
4	My child thoroughly enjoys exchanging ideas on the SG game with other children.
5	My child often participates in activities relating to the SG.
(7)	***Leisure time***
1	I am satisfied with my child's leisure time: My child has the opportunity to do what they want in order to relax and enjoy.
2	My child's leisure time is important for his/her quality of life.
(8)	***View of Life (How I view my child's life)***
1	I am satisfied with how I view my child's life: I know what means a lot to my child, and what they want to do with his/her life.
2	How my child views his/her life is important for his/her quality of life.
(9)	***Creativity***
1	My child is satisfied with opportunities to be creative: to get to use their imagination in everyday life, for example, in a hobby (e.g. playing the SG game), on the job, or in studies.
2	Being able to be creative is important for my child's quality of life.
(10)	***Learning***
1	I am satisfied with my child's learning: He/She has the opportunity and desire to learn new, exciting things and skills that interest him/her.

2	Learning is important for my child's quality of life.
(11)	***Friendship Quality***
1	My child is satisfied with friends and friendship: He/She has friends that he/she can associate with and who can support him/her (as many friends as he/she wants and needs).
2	Friends and friendship are important for my child's quality of life.
(12)	***How I view my child as a person***
1	I am satisfied with how I see my child as a person: He/She likes and respects himself/herself.
2	My child's satisfaction with himself/herself is important for his/her quality of life.