Does Playing Video Games Give a Child an Advantage in Digital Game-Based Learning?

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Abstract. In this paper we first investigated the relationship between game habits of primary school children and their school achievements and anxiety levels. Then, we investigated if children habitually playing video games at home have an advantage when it comes to learning using educational games. In order to answer these questions, we exploited the data coming from the digital game-based learning (DGBL) intervention *Happy Maths*, a 6-week programme run in Irish primary schools aimed to increase maths abilities and decrease maths anxiety (MA). The dataset contained the academic achievements, the video game habits and the intervention data of 952 pupils. Our results show how playing games at home that are not age-appropriate was associated with higher MA and lower maths score, while time spent playing was associated with higher MA and lower literacy score. Regarding the efficacy of the DGBL intervention, there was no difference in the efficacy of the intervention between gamers and non-gamers. However, habitual video gamers were faster in executing their game moves, and they achieved higher scores, learning the game better. Overall, the study underlines the importance of playing age-appropriate games, and it provides evidence that, although kids playing video game might have a good advantage when it comes to educational games, the efficacy of such games is the same for gamers and non-gamers.

Keywords: digital game-based learning · academic achievements

1 Introduction

It is estimated that almost 3 billion people played video games in some capacity in 2022, with a prevalence among adolescent of about 75%, approaching 90% in industrialized countries [16]. Since video gaming is such a widespread activity, the link between playing video games and the cognitive and emotional traits of players has been subject to extensive attention. Multiple reasons have been proposed to explain the potential link between video gaming and academic achievements. In [11], authors summarise previous relevant theories. According to the *time displacement* hypothesis, computer gaming replaces time that should be invested in academic activities [22], causing lower academic scores. According

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to the *sleep displacement* hypothesis [14], computer gaming reduces both the quantity and the quality of sleep, causing lack of attention and poorer cognitive abilities [9]. In the *attention deficit* hypothesis [10], it is assumed that prolonged computer gaming takes away time from tasks that would otherwise contribute to the development of sustained attention and therefore decrease players' cognitive performance and their ability to focus. In contrast to these negative views, the *cognitive enhancement* hypothesis [20] suggests that games might also act as training programs for various cognitive skills, such as attentional capacity, visual orientation, and memory, which might improve players' cognitive abilities.

Experimental studies to date seem to support both perspectives. Some studies reported poorer test performance for students spending a lot of their time playing games [3,17], but several researchers found significantly better performance on standardized tests of cognitive abilities among gamers as compared with non-gamers [13,18], or no effects at all [8]. In [4], a meta-analysis found that regularly playing computer games was associated with cognitive gains corresponding to Cohen's d between .30 to .70. A large study of the PISA results of more than 192000 students from 22 countries [16] found only a negligible difference in academic performance across the relative frequencies of videogame use, concluding that video games had little impact on academic achievements. While these studies were cross-sectional, and therefore can only report an association between games and academic achievements, a recent large-scale longitudinal study on 3500 German adolescents found that playing computer and video games can result in a noticeable, albeit small, loss of educational achievements, but it does not affect basic competences [11].

The effect of video games was found to be dependent on the type of game played. In [5] the author found that multi-player gaming, rather than single-player gaming, was linked with lower performance in reading. In [15], the authors focused on a group of 70 kids aged 6–10 and found a negative correlation between academic scores and time spent playing games, but only for violent video games. Educational games were related to good academic achievements.

Video games have been investigated also in relations to depression and anxiety. While a moderate use of video games does not seem to have relationship with anxiety, problematic game behaviour and excessive use were clearly linked with anxiety and depression. Excessive use of video games can lead to IGD (internet gaming disorder), a recognized mental disorder that has an estimated prevalence of 10.6% among teenagers [21] and it is strongly correlated with anxiety. Indeed, a recent study has found that 92% of players suffering from IGD also have anxiety [12], providing further evidence of the strong correlation between the two conditions. However, the directionality between game habits and anxiety has not been disentangled. There is evidence that anxiety might precede problematic game behaviour, but it has also been observed that excessive gaming can increase an existing anxiety. Evidence to date on the link between gaming and anxiety is inconsistent.

A recent study of 97 21-year-old participants [2] found no statistically significant difference in anxiety levels or daytime sleepiness between expert and non-expert players, where expert and non-expert players were identified by the time spent playing action video games. There is indeed a line of research investigating how games can be used to alleviate anxiety. A recent meta-analysis [7] investigated the effect of game-based interventions to reduce maths anxiety, reporting a small positive effect size of 0.24.

The present study seeks to investigate further the link between video games and some cognitive and emotional traits of players with novel contributions. In the first part of the paper, a traditional cross-sectional study is presented, in which we studied the relationship between game habits and three outcome variables, namely students' maths scores, literacy scores and maths anxiety. Therefore, our first set of research questions was:

RQ1. *Are game habits associated with academic performance in (a) maths, (b) literacy and with (c) maths anxiety in primary school kids (age 8–11)*?

Our cross-sectional study provides new evidence in a still inconsistent landscape. It focuses on primary school children, for which fewer studies have been published. Moreover, a novel predictor was considered, namely the *age rating* of the games habitually played by each participant, introduced in order to understand if the games played were appropriate to the age of the child. Our hypothesis is that, when it comes to young children, the age rating of the game, rather than the content, could significantly impact the above outcome variables.

In the second part of the paper, we investigated a novel research question. We wondered if the familiarity with video games can impact the efficacy of a maths digital game-based learning (DGBL) intervention in school. In other words, we wondered if habitual gamers have an advantage when learning using (educational) games. Multiple hypothesis supports this statement: (1) habitual gamers could be more engaged and motivated when learning with games than non-habitual gamers, (2) they could be less sensitive to computer or technology anxiety and (3) they might have acquired specific skills by playing digital games that could make more effective the way they learn with educational games. We were interested in testing two related aspects. The first is whether players' video game habits can affect players' performance in an educational game. Game performance in an educational game is not merely an indicator of how good a player is, but it is indeed a proxy for maths performance and, according to studies in game-based assessment, it can be a more fair and precise form of assessment for certain groups of students. The second aspect is whether habitual gamers learn in the same way as non-gamers after a DGBL intervention, where learning is measured by comparing the results of a relevant maths test administered before and after the DGBL intervention. Our second set of research questions was therefore the following:

RQ2. *Do game habits of students predict students' performance in an educational game? Do game habits of students predict the effects of a DGBL intervention?*

In order to answer RQ1 and RQ2, we exploited the data of the DGBL intervention *Happy Maths*, including a set of in-game data and the results of the paper maths test administrated pre- and post- intervention. It is important to report that data from the *Happy Maths* programme [1] showed that, after the *Happy Maths* DGBL intervention, children had a lower number of errors in the post maths test (effect size of 0.35) and a reduced maths anxiety (effect size 0.19). Here, we wondered if such positive effects were associated with the game habits of the participants.

2 Methods

Data collection was performed from January 2022 to May 2023 in the context of *Happy Maths* [1], a research project investigating the effects of DGBL on primary school students' numerical cognition and maths anxiety. The study was a quasi-experimental intervention with a pre-post design and weekly game sessions delivered in class for six consecutive weeks. At the beginning of the study, information on children's game habits was collected via a questionnaire containing items about how much time the respondents spent playing video games daily, how much they enjoyed playing videogames and the list of favourite videogames usually played. For each game, we collected its age rating as suggested by the Entertainment Software Rating Board (ESRB), that assigns to each game one of the following categories: E (everyone), E10+ (everyone above 10-year-old), T (teenager), M (mature player) and A (adult).

Additional measures were collected. Pupils were asked to fill the Modified Abbreviated Maths Anxiety scale [6], a validated scale for primary school kids to measure their level of maths anxiety (MA). Data were collected pre- and post-intervention. In a similar way, pupils were asked to fill a maths test pre- and post- intervention. The test covered the maths content of the games. Moreover, for each student, their maths score and literacy score were gathered by collecting the results obtained in the Irish national standardize test for maths and English. Results were provided in the range 1 to 10. Demographic data such as gender and age were also collected.

Fig. 1. The *Seven Spells solo* mode (left) and *versus a human* mode (right).

Children took part in a 6-week DGBL intervention in class called *Happy Maths*. Each week a 1-hr session was delivered by at least two members of the *Happy Maths* research team. The intervention is designed around the digital game Seven Spell [1], a card game to stimulate problem-solving, numerical skills and strategic thinking (Fig. 1). Aim of the game is to capture the other player's number cards using various maths abilities, including arithmetic computations, knowledge of mathematical concepts (even and odd numbers, prime numbers, numeric tables, intervals, greater and smaller, etc.) and players' ability to combine and manipulate numbers. The more cards a player captures, the higher their score. A good move requires the player to combine multiple cards, allowing players to build from simple to very complicated moves and to exercise their own creativity and tactics. In order to answer RQ2, we used game logs and game performance data and we extracted the following in-game measurements: the average score of each player at week 1 and at week 6 (that is at the end of the intervention) and the average duration of each move across the 6 in-class sessions.

3 Results

The dataset contained complete data for 952 players. Tables 1 and 2 show the descriptive statistics for the numerical and categorical variables included in the study. A total of 216 games was mentioned; the most frequently mentioned games were Fortnite, FIFA, Minecraft and Roblox. Boys' and girls' game preferences were quite segregated; only 45 games (20.8%) were played by both boys and girls, 54 by girls only and 117 by boys only. However, the 45 games in common were the most popular, and they were played by 79.4% of girls and 75.7% of boys. The game mostly played by girls was Roblox (played by 48.7% of girls and only 12% of boys) and the game mostly played by boys was FIFA (6.9% of girls vs. 32.7% boys), while Minecraft was the most *equally* played game (28.4% of girls vs. 25.3% of boys).

Table 1. Numerical study variables (N = 952).

Variable	Description	Mean	SD	Range
MA	Maths Anxiety score (mAMAS)	20.7	7.47	9–45
MS	Maths Score	5.88	2.14	1–10
LS	Literacy Score	5.87	1.99	1–10

Table 2. Categorical variables considered (N = 952). The variable *Class Yr.* refers to the levels in the Irish school system: 3rd class refers to 8-year-old children, 4th class refers to 9-year-old, 5th class refers to 10-year-old and 6th class refers to 11-year-old children.

Variable	Description	Distribution of levels
Class Yr.	Class grade	14,5% (3rd), 20.8% (4th), 32.5% (5th), 32.2% (6th)
Gender	Binary variable M,F	F = 394 (41.4%), M = 558 (58.6%)
Likevideo	Do you like video games? Likert scale (1 = hate 5 = love)	1: 4.2%, 2: 2.8%, 3: 8.0%, 4: 25.8%, 5: 59.2%
PlayTime	How much do you play video games daily?	Never: 6.8%; $\leq$ 1 h: 21.4%; 1–2 h: 36.1%; $\geq$ 2 h: 35.7%
ESRB	ESRB Rating	E: 30.7%; E10+: 23.1% T: 36.8%; M: 9.4%

3.1 Impact on Academic Achievements and Maths Anxiety

Table 3 shows the results of three linear regression models, each of them predicting one of the outcome variables of interest: maths anxiety (MA), maths score (MS) and literacy score (LS). The predictors used were gender, class year, the *age rating* of the games played by each player, the time spent playing videogames (variable *Timep*) and how much video games are enjoyed (variable *likeVG*). For each player, the value of the *age rating* variable was computed as the highest ESRB age rating among the games played by the player. The ratings M (mature) and A (adult) were grouped into the M rating. Therefore, the *age rating* was a categorical variable with four levels (E, E10+, T, M). The idea behind the *age rating* variable was to measure if a player was habitually exposed to content that was not appropriate to their age. In the regression models of Table 3, the rating E was used as reference. The significant predictors are shown in bold, and the p-value for each predictor is reported in parentheses. The variables describing game habits were significant: *age rating* was significant in the model predicting MA and MP, *TimeP* was significant for MA and LS, while *LikeVG* for MP.

We also noticed how the average level of MA varied by the age rating of the games, but the variation was mainly for girls and not for boys, as shown in

Table 3. Linear regression models to predict maths anxiety (MA), maths score (MS) and literacy score (LS) using predictors related to game habits (p-values are shown in parentheses, significant predictors at 0.05 level are shown in bold).

Y	Gender = M	Class Yr.	E10+	T	M	TimeP	LikeVG	R^2
MA	**−3.82*** (<0.001)**	−0.14 (0.61)	0.62 (0.51)	**1.76** (0.015)**	1.86 (0.053)	**1.43 (<0.001)**	−0.19 (0.58)	9.55
MS	**0.55*** (<0.001)**	0.02 (0.75)	0.29 (0.26)	**−0.60*** (<0.001)**	−0.32 (0.41)	−0.19 (0.068)	**−0.22* (0.017)**	5.33
LS	0.09 (0.56)	−0.003 (0.96)	**0.78** (0.004)**	0.32 (0.15)	0.10 (0.72)	**−0.28** (0.007)**	−0.17 (0.087)	4.41

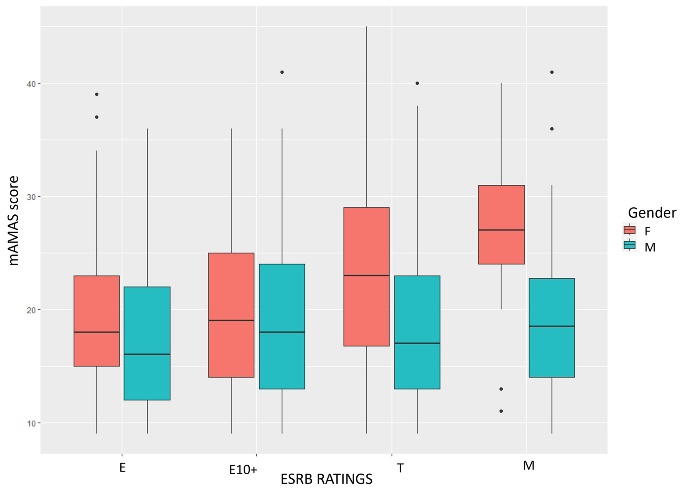

Fig. 2. Average maths anxiety by gender and by the age rating of the games habitually played by each student.

Fig. 2. We therefore fitted a model including an interaction term between gender and age rating. Table 4 shows the result of the obtained model: the interaction term was significant and the R^2 of the model was improved.

3.2 Impact of Video Game Habits on the DGBL Intervention

We tested the effect of video game habits on the outcomes of the *Happy Maths* intervention and on the game performance achieved in the educational game. In the introduction of this paper we reported how the *Happy Maths* programme [1] was effective in reducing the number of errors in a post-intervention maths test (effect size of 0.35) and maths anxiety levels (effect size 0.19). However, even if the intervention had an effect, we wondered if the effect of the intervention could be explained by the game habits of the participants. Moreover, by looking at game logs, we wanted to understand if video game habits at home affected the way children played the educational game. We studied the following outcome variables: the pre-post difference in maths anxiety (Δ_{MA}), the pre-post difference in the number of errors in the paper maths test (Δ_{ME}) and the following three in-game measures: average duration of a move, game performance (measured by the average of the two highest scores achieved in the game by each player), and the difference in game performance between the first and the last week of the intervention (Δ_{Score}). We added to the list of predictors maths score, literacy score and maths anxiety, in order to fully test if the effect of the game habits variables was present even after controlling for the cognitive abilities and anxiety levels of the players. Results are shown in Table 5, where each line represents a linear regression model for one of the outcome variables considered.

Table 4. Linear regression model to predict Maths Anxiety containing an interaction term between gender and the age rating of the games played.

Predictor	β	Pr(> |z|)	Predictor	β	Pr(> |z|)
Gender (M)	1.02	0.27	TimeP	1.31	(<0.001)
Class Yr.	−0.16	0.54	LikeVG	−0.23	0.51
E10+	0.40	0.82	Gender(M)*E10+	−0.25	0.91
T	**3.55**	**0.024***	Gender(M)*T	−2.99	0.068
M	**7.41**	**0.002****	**Gender(M)*M**	**−6.76**	**0.009****
Observations = 952, R^2 = 10.95					

Table 5. Linear regression models to predict the effect of a DGBL intervention using players' game habits (p-values are shown in parentheses, significant predictors at 0.05 level are shown in bold).

Outcome	Gender (M)	Class Yr.	MP	LS	MA	TimeP	LikeVG	R^2
Δ_{MA}	0.49 (0.26)	0.33 (0.25)	0.24 (0.14)	−0.18 (0.28)	–	0.53 (0.13)	−0.02 (0.96)	1.1
Δ_{ME}	0.51 (0.21)	**−0.49* (0.02)**	**−0.48*** (<0.001)**	−0.03 (0.78)	0.03 (0.37)	0.02 (0.92)	0.09 (0.73)	10.2
Mean Duration	**−2.99 (<0.001)**	−0.26 (0.18)	**0.53*** (<0.001)**	−0.19 (0.22)	**0.10*** (<0.001)**	−1.06*** (< 0.001)	**0.63* (0.04)**	14.7
Mean Score	15.4 (0.40)	**25.4*** (<0.001)**	**41.07*** (<0.001)**	3.65 (0.49)	**−3.05** (0.01)**	**20.2* (0.05)**	6.08 (0.57)	21.1
Δ_{Score}	**−33.4* (0.05)**	8.49 (0.19)	**28.3 (<0.001)**	−4.27 (0.40)	**−2.58* (0.03)**	**22.1* (0.02)**	4.84 (0.61)	14.1

4 Discussion

Regarding the effect of game habits on school achievements and maths anxiety (RQ1), our data showed how the age rating of the games played was a significant predictor even after accounting for player's gender and age. Regarding MA, playing games rated for teenagers (T) or for a mature audience (M) increased the maths anxiety of the player by about 1.8 point (about 0.26 SD). However, the most interesting result was the interaction between gender and the age rating of the games played, whereby the effect of *age inappropriate* videogames was stronger for girls than for boys. In the model without an interaction term, girls had an average MA level 3.82 points higher than boys, while in the interaction model girls playing games rated M had an average MA level 5.74 points higher than boys. The model with the interaction term was a better fit for the data (R^2 of 10.95 compared to 9.55).

Age rating was also significant for maths score and literacy score. Playing games rated T decreased maths score by 0.60 (on a scale 1–10), while playing games rated for everyone (E) increased literacy score by 0.78, This is consistent with [15], that found an association between playing violent video games and lower academic achievements. However, by considering the age rating of each game, our study goes beyond [15]. Indeed, age rating is not only assigned considering the level of violence in a game, but many other factors such as language, sex, tension, storyline, how safe the communication among online players is and so forth. Our study suggests the importance for children to play games appropriate to their age and the importance of supervision when playing.

Regarding the time spent playing video games, it had a significant effect on increasing MA. An explanation could be that habitual players might be the ones at risk of developing problematic game behaviour, that is strongly associated with anxiety [12,19]. Time spent playing also affected literacy score negatively, while it did not affect maths score, in accordance with [5].

In the second part of our analysis we wondered if the effect of a DGBL intervention depended on the game habits of players (RQ2). We found no significant associations between the learning outcome of the *Happy Maths* intervention (variable Δ_{ME}) and the players' game habits (variables *TimeP* and *LikeVG*). The same was true for MA reduction (variable Δ_{MA}). Therefore, even if the intervention had an effect, it was not explained by the game habits of players.

Habitually playing video games gave an advantage in the educational game, since *TimeP* was a significant positive predictor of higher game scores even after controlling for cognitive abilities, age and maths anxiety of the student. Playing games habitually gave also a significant advantage in terms of how much a student improved their game scores from week 1 to week 6 of the intervention. Likewise, habitual gamers and video games lovers (variable *LikeVG*) were much faster in executing their moves in the game, as evidence of their higher familiarity with the mechanics of digital games.

In summary, being a habitual player did not give an advantage in learning measured by traditional assessment methods, however it gave an advantage with respect to the performance in the educational game. Since scoring a high score in the game requires to perform maths tasks similar to the ones presented in the pre- and post- paper maths test, we wondered why habitual players had higher game scores but not higher test scores. Several explanations are possible. One explanation could be that the game environment might have engaged and stimulated kids differently, with some players more enthusiastic to play and motivated by the competition aspects of the game and some other less motivated. Moreover, players might have felt less motivated or focused doing a test on paper, since the test was not linked to any reward. Other explanations could be that the game and the test, although similar, were not perfectly aligned in terms of content, or that the game did not affect maths abilities outside the game. However, data from the *Happy Maths* programme evaluation show how after playing the game kids improved their paper test scores, as evidence that the educational game had an effect. In addition to all of these explanations, we also mention that test anxiety might have been present in the paper test and absent in the game, while technology-related anxiety could have been present in the game and absent in the test, both factors influencing students' performance. In order to fully answer our question, further analysis and controlled studies should be implemented to isolate the reasons why the performance of some students differed between the game and the test. As they stand, our results are interesting to show that habitual players played educational games in a more effective way than non-habitual players, suggesting that game-based learning could be a more truthful form of assessing the maths level of this group of children.

5 Conclusion

In this paper we contributed to the study of the relationship between game habits and cognitive and non-cognitive traits of players. In the first part of the paper, we described a cross-sectional study investigating the relationship between game habits with three outcome variables: maths score, literacy score and maths anxiety. Our results showed how playing games that are not age-appropriate was associated with higher MA and a lower maths score, while time spent playing was associated with higher MA and a lower literacy score. In the second part of the paper, we tested if game habits affected the outcome of a DGBL intervention in school. Our results showed that there was no difference in the efficacy of the intervention between habitual gamers and non-gamers with respect to MA reduction and maths learning. However, habitual video gamers were faster in executing their game moves, they achieved higher scores and learnt the game better. Overall, the study underlines the importance of playing age-appropriate games, and it provides evidence that, although kids playing video game might have good advantage when it comes to educational games, the efficacy of such games is the same for gamers and non-gamers. We also showed that habitual players played educational games in a more effecting way, suggesting that game-based learning could be a more truthful form of assessment for these students.

References

1. The Happy Maths Programme. https://www.happymaths.games. Accessed 31 May 2013
2. Alsaad, F., et al.: Impact of action video gaming behavior on attention, anxiety, and sleep among university students. Psychol. Res. Behav. Manag. 151–160 (2022)
3. Anand, V.: A study of time management: the correlation between video game usage and academic performance markers. Cyber Psychol. Behav. **10**(4), 552–559 (2007)
4. Anderson, C.A., et al.: Violent video game effects on aggression, empathy, and prosocial behavior in eastern and western countries: a meta-analytic review. Psychol. Bull. **136**(2), 151 (2010)
5. Borgonovi, F.: Video gaming and gender differences in digital and printed reading performance among 15-year-olds students in 26 countries. J. Adolesc. **48**, 45–61 (2016)
6. Carey, E., Hill, F., Devine, A., Szűcs, D.: The modified abbreviated math anxiety scale: a valid and reliable instrument for use with children. Front. Psychol. **8**, 11 (2017)
7. Dondio, P., Gusev, V., Rocha, M.: Do games reduce maths anxiety? a meta-analysis. Comput. Educ. **194**, 104650 (2023)
8. Drummond, A., Sauer, J.D.: Video-games do not negatively impact adolescent academic performance in science, mathematics or reading. PLoS ONE **9**(4), e87943 (2014)
9. Dworak, M., Schierl, T., Bruns, T., Strüder, H.K.: Impact of singular excessive computer game and television exposure on sleep patterns and memory performance of school-aged children. Pediatrics **120**(5), 978–985 (2007)
10. Gentile, D.A., Swing, E.L., Lim, C.G., Khoo, A.: Video game playing, attention problems, and impulsiveness: evidence of bidirectional causality. Psychol. Pop. Media Cult. **1**(1), 62 (2012)
11. Gnambs, T., Stasielowicz, L., Wolter, I., Appel, M.: Do computer games jeopardize educational outcomes? a prospective study on gaming times and academic achievement. Psychol. Popular Media **9**(1), 69 (2020)
12. González-Bueso, V., et al.: Internet gaming disorder in adolescents: personality, psychopathology and evaluation of a psychological intervention combined with parent psychoeducation. Front. Psychol. **9**, 787 (2018)
13. Green, C.S., Seitz, A.R.: The impacts of video games on cognition (and how the government can guide the industry). Policy Insights Behav. Brain Sci. **2**(1), 101–110 (2015)
14. Hale, L., Guan, S.: Screen time and sleep among school-aged children and adolescents: a systematic literature review. Sleep Med. Rev. **21**, 50–58 (2015)

15. Hastings, E.C., Karas, T.L., Winsler, A., Way, E., Madigan, A., Tyler, S.: Young children's video/computer game use: relations with school performance and behavior. Issues Ment. Health Nurs. **30**(10), 638–649 (2009)
16. Islam, M.I., Biswas, R.K., Khanam, R.: Effect of internet use and electronic gameplay on academic performance of Australian children. Sci. Rep. **10**(1), 1–10 (2020)
17. Jackson, L.A., Von Eye, A., Fitzgerald, H.E., Witt, E.A., Zhao, Y.: Internet use, videogame playing and cell phone use as predictors of children's body mass index (BMI), body weight, academic performance, and social and overall self-esteem. Comput. Hum. Behav. **27**(1), 599–604 (2011)
18. Kovess-Masfety, V., et al.: Is time spent playing video games associated with mental health, cognitive and social skills in young children? Soc. Psychiatry Psychiatr. Epidemiol. **51**(3), 349–357 (2016)
19. Männikkö, N., Ruotsalainen, H., Miettunen, J., Pontes, H.M., Kääriäinen, M.: Problematic gaming behaviour and health-related outcomes: a systematic review and meta-analysis. J. Health Psychol. **25**(1), 67–81 (2020)
20. Powers, K.L., Brooks, P.J., Aldrich, N.J., Palladino, M.A., Alfieri, L.: Effects of video-game play on information processing: a meta-analytic investigation. Psychonom. Bullet. Rev. **20**, 1055–1079 (2013)
21. Singh, Y.M., Prakash, J., Chatterjee, K., Khadka, B., Shah, A., Chauhan, V.S.: Prevalence and risk factors associated with internet gaming disorder: a cross-sectional study. Ind. Psychiatry J. **30**(Suppl 1), S172 (2021)
22. Subrahmanyam, K., Renukarya, B.: Digital games and learning: identifying pathways of influence. Educ. Psychologist **50**(4), 335–348 (2015)