Digital Experience and Cognitive Development in Primary School Students

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Abstract. In this study, authors examined a children experience of using digital devices and its relationships with children's cognitive development. Previous research has shown contradictory findings that reflected associations between children engagement with digital technology usage and cognitions. The study approved hypothesis about qualitative changes in children's digital experience after one year. In just one year the landscape of the known by children mobile apps has significantly transformed and expanded. Children continue to master their digital opportunities in the field of those mobile apps which are widely used by adults. The results of the study show there is a qualitative leap in the digital experience of children who hold down in their minds not only the apps that they usually use but also apps related to them. However, adults tend to associate the digital experience with negative consequences. The findings of this study have shown positive connections between the digital experience, cognitive development and learning outcomes of children. It could be supposed that cognitive development is accompanied by enrichment of the digital experience which is its integral part in modern conditions of children's mental development.

Keywords: Primary School Age, Digital Technology Usage, Apps, Digital Experience, Children, Cognition, Memory, Attention

Introduction

Modern children develop and live in technology-saturated environment [6; 7; 10; 22; 27; 41]. Most of them begin to use digital devices earlier than learn to speak. Some of them have had their own digital devices before they started going to school. These children don't know the world without Internet-based technology and perceive physical and a virtual reality inseparably [12; 34]. Evidently, they get into the swing of solving their tasks and satisfying their needs with mobile apps. In the light of L.S. Vygotsky's sociocultural theory of children development [48] digital devices have become one of the most influenced cultural tools affected developing child's cognitions.

Moreover, modern children interact constantly with both human and nonhuman mediators in their perception and communication with the rapidly changing world [24]. The fundamental changes of sociocultural landscape of Childhood lead to different ways of cognitive and social development of modern children, compared with their predecessors' development. Such a situation has become one of the most discussing issues in modern psychological literature over the last decades. Researchers indicated that mental transformations in children development express themselves through decreasing number of children with average intellect and growing polarization of developmental levels in children [17; 40]. Psychologists tend to warn of decrease of cognitive activity, declining of mnemonic and attention skills, and impaired imagination [5; 9; 17; 40; 45]. However not the all researchers have agreed with such a negative impact of digital technology on children development. Those who investigated an association between digital technology use (DTU) and cognitive development of children reported rather contradictory results. It was indicated by a number of studies that there was positive impact of computer games on visual spatial and spatial reasoning skills, perceptual motor skills, creativity, and reaction time [18; 23; 26; 28; 30; 46; 51]. By contrast other studies didn't reveal any connections between DTU and children's cognition [20; 33; 38], or showed negative effects of DTU manifested in a decrease in verbal memory performance and increased inattention [19], decreased academic achievement [3; 13; 25]. Thus it is needed to continue investigations for examining connections between DTU and cognitive skills of children. Moreover, the most of studies in this area were conducted with samples from adolescence to older. There is not clear picture of relationships between DTU and children cognitive development in primary school age. So this paper raised next research questions:

- What changes have been occurring in children's digital experience during the primary school age?
- What connections might be found between DTU and children's cognitive development in primary school age?
- How does digital experience mediate academic outcomes of children?

Therefore, the main objective of this study was to examine relationships between children digital experience, their academic outcomes and cognition. Another aim of the study was to evaluate change in children' digital experience under natural conditions of their development over one year. We tested the hypothesis that digital experience of children connected to their academic outcomes and level of cognitive skills' development. We also hypothesized that there could be qualitative changes in children's digital experience after one year.

1 Digital Technologies and Cognition

The modern world has been taking on much more digital-based features that remade the usual ways of thinking and problem-solving [16]. So mobile devices can help an individual to add technical tools to the act of thinking at any moment when, for example, he or she needs to gain relevant information, evaluate a product or calculate the necessary expenses.

Augmented human cognition not only adds efficiency to an individual's life, but it might alter the cognitive process itself. It is clear that widespread use of calculators has dramatically reduced basic arithmetic fluency [29], digital address book function on smartphones facilitated to displace part of human memory to digital space [4], and so on. Nowadays people don't need to keep in mind the content of necessary information for decision making they rather need to know where they can find that information. It turns smartphones into sources of transactive memory or an external memory store [44]. D. Dennett has called an inclusion of external tools in internal cognitive processes as situated cognition [14]. The extended mind is another definition of cognitions when they are acting with help of the environmental tools [8].

Despite of all the benefits of digital devices' usage, fears about transformation of mental processes by digital technologies were occurred in press and scientific literature more and more often [2; 5; 9; 15; 17; 40; 45]. These anxieties have been spurred by digital divide between generations. Adults have never been lived as children in a technologically complicated environment and do not know precisely what upbringing practices might be useful for digital natives [35]. Nonetheless, Henry H. Wilmer, Lauren E. Sherman and Jason M. Chein have shown in their review of studies exploring the connection between mobile technology habits and cognitive functioning that smartphone usage and attention have rather negative relationships. They also have found some evidence that mobile devices habits might have negative impact on mnemonic functioning [49]. At the same time, most of research was based on self-report questionnaires that rather estimated DTU habits than breadth and content of digital experience. Another issue is related to what cognitive functions are more suitable for changing social conditions and might provide a more successful adaptation to a complex environment of modern life.

2 Method

2.1 Participants and procedures

The study involves 235 children aged between 9 and 10 (110 girls (46,8%), mean age 9,53 SD=0,51). All of the children were within the range of normal without any disabilities or developmental delays. There were 110 3rd graders (45,6% girls) and 125 4th graders (48,00% girls) of one of Saint-Petersburg schools (Russia). The study was a part of the large-scale monitoring of mental and social development of school students so parents gave permission to participate their children earlier. Notwithstanding information about this study was presented to parents on parent-teacher meetings. Parents were informed about goals and objectives of the study, and stages of their children's participation in the study. The study was conducted in school during children-psychologist meetings. Each child was examined individually, apart from others in a school psychologist's office. Additionally, 11 teachers were asked to assess children's engagement with DTU. Teachers filled Evaluation of the child's engagement with DTU for each child in their classes separately.

The monitoring is carried out annually, and the digital experience measurement included in the monitoring second year. In this regard we conducted data screening to identify children that had 2 year of measures for digital experience. There were 62 3rd graders (41,94% girls) and 93 4th graders (54,84% girls) who had both Icon Recognition test scores and teachers' evaluation of engagement with DTU from the 2018 year's study [35].

2.2 Measures

2.2.1. Digital Experience

In this study we used three types of a source of information to measure digital experience. It couldn't possible to use self-report questionnaires because children don't have enough abilities to estimate the amount of time which they have spent using mobile devices. In regard to this matter, the Icon Recognition Test was used with children for direct estimation of their digital experience and recognition of different types of mobile apps. At the same time, we used an indirect assessment of digital experience by means of teachers' evaluations of child engagement with DTU and peers' evaluation of the child digital experience through digital sociometry.

Icon Recognition Test (IRT). This test was used to estimate an experience of children with mobile devices [35]. The IRT contains 25 app's icons and 25 foil pictures without any verbal captions under pictures. Three types of apps were used including standard icons for calling, texting, shooting and keeping photos, social media apps, and games apps. The children were asked to choose those pictures that they could earlier see on screens of any devices. We instructed them not to guess but check only those pictures in which they are sure. An amount of icons selected minus an amount of foils selected was calculated as the total scores. The test had a high internal reliability (Cronbach's Alpha (standardized) α=0.77, split half r=0.81).

Digital Sociometry. Sociometry is well known as a qualitative technique created by J.L. Moreno to measure degree of relatedness among people. Sociometry is based on choices that people make in interpersonal relationships. The choices are made on the basis of some criterion. We used the criteria which was adopted for the aims of the study. Children were asked to choose up to five classmates whom they would contact if they need to learn something about mobile phones. Additionally, children had to choose up to five classmates whom they would not contact in such a situation. Digital sociometric status (DSS) was calculated by subtracting negative nominations from positive choices referred to the total amount of pupils in the class. DSS was identifying as peer acceptance and rejection in relation to the child's digital experience.

Teacher's evaluation of the child's engagement with DTU Scale. A ten-pointed Likert scale (1-almost not interested in DTU; 10- excessive interested in DTU) was used to evaluate children's engagement with DTU by teachers (TE).

2.2.2. Cognitions

We examined different cognitive skills including memory skills, attention, and thinking abilities (generalization, causal inference, comprehension). All the techniques used were selected according to their capacity to predict successful learning outcomes and the children age.

Memory tests. We used two memory test developed by L. M. Shipitsyna [37]. These tests based on the ten words technique which was proposed by A.R. Luria. Children were provided with two sets of ten objects to measure visual and auditory working memory. The first set contained 10 pictures of objects (cat, umbrella, bag, chair, clock, pyramid, fish, butterfly, bucket, hedgehog). Children were asked to remember what was painted on the pictures and to write it after the presentation. The visual memory scores were calculated as the sum of the correctly reproduced words. The second set included ten words (mountain, star, window, bun, handle, soap, spring, glasses, book, squirrel). The words were spoken to the children and, after that, the examiner asked them to write down the remembered words. The auditory memory scores were calculated in the same way as the sum of the correctly reproduced words.

"The Fourth Superfluous" Test. The test includes five sets of words [37]. There were four words in each set (like, a sparrow, a tit, a dove, and a bee). Three of them could be combined into one group whereas the fourth word didn't belong to this group. Children were asked to find the fourth superfluous word and to name the group formed by the remaining words. This test was used to measure generalization strategies and ability to highlight the essential features of objects. The overall score was calculated as a sum of the correct choices.

Picture Arrangement Test "Sequential Pictures". The test contains three series of comic-strip pictures presented in a mixed-up order [37]. The task of examinee is to arrange them in the right sequence to tell a story that makes sense. The first set of pictures has four sketches ("a key"), the second one has five sketches ("a swimmer"), the last set of pictures has six sketches ("dodgers"). The test was used to assess a child ability to understand social situations and to generate appropriate inferences about causal relations of events. The causal inference scores were calculated as a sum of correct arrangements of pictures.

"Absurdities in the Picture" Test. The "Absurdities in the Picture" test contains the picture where animals are located in the ridiculous situations (for example, a cat in a nest, a goose on a chain in a dog-house, etc.) [31]. Children were asked to find everything that seems to them strange and wrong. After that the examiner asked them to explain what is wrong and how should it actually be. The task time was limited to three minutes. The test was used to evaluate the child's elementary representations of the surrounding world, his or her comprehension of logical connections that exist between particular objects of the world (animals, their way of life, and nature at whole). The overall scores were calculated as a number of inconsistencies found, corrected for ability to explain the absurdities of situation.

The Piéron-Rusen test. The Piéron-Rusen test is a well-known technique used in Russia over a long period of time [39]. This test had been developed by H. Piéron as a modification of Bourdon test and, after that, the test has undergone a significant modification implemented by Russian psychologist E.I. Rusen in the third decade of the twentieth century. The test contains a sequence of geometrical figures (triangles, circles, rhombs, squares). There are 10 rows of 10 geometric shapes. Children were instructed to fill different figures by different symbols. Squares should be marked by plus, triangles should be marked by dashes, rhombs by points. Circles should remain unmarked. Children had 60 second to complete the test. The test is intended to measure a sustained attention's level. Three indicators of sustained attention were measured including number of correctly filled figures (correctness index), number of mistakes, and the level of sustained attention.

2.2.3. Learning outcomes

In this study we used last quarter grades (QG) in core subjects (Language, Math, Reading) and reading skills development test by L. A. Yasyukova [50]. The Yasyukova test is considered a measure of a level of reading skills as a part of universal learning actions. The test contains excerpt from a fairy tale where words are omitted in sentences. The task of examinees is to fill missing words fitted the meaning of the sentence. The task time is limited to seven minutes. The overall score was calculated as a sum of correctly filled words according to the test keys.

2.3 Data Analysis

In this study descriptive and comparative analysis to evaluate gender and grade level differences were conducted. Gender, grade level, and digital experience were determined as independent variables. We split up the sample into three groups according to the parameters of digital experience (low, middle, and high level) using cut-off values ($\bar{x} \pm \frac{1}{2} s$). We used analysis of variance and Pearson chi-square criteria for comparative analysis, the related samples were compared by the Sign test procedure to identify qualitative changes in children digital experience after one year. The next step was performed by analyzing a correlational structure of all the study variables. All analyses were calculated in Statistica v. 6.1 (StatSoft Inc.).

3 Results

The results of recognition of mobile apps icons according gender and grades of education are shown in Table 1. The Table 1 also contains results of comparison of icons' recognition for paired longitudinal samples by the Sign test procedure. For two inferential samples, a qualitative leap in digital experience was found. Children recognize mobile apps significantly better after one year. The enhancements were revealed among the recognition of icons of social media apps, Google apps, and standard smartphone features. At that, these enhancements less concerned with the recognition of game apps. There were no significant differences in recognition of the most mobile games' icons (Masha and The Bear, Fiksiki, Tree cats, LEGO, Monster Trucks racing game, Toy Pop Cubes). We also didn't find significant correlation between IRT scores 2018 and 2019 years (r=0,03; p>0,05). However, significant correlation between TE scores 2018 and 2019 years was revealed (r=0,70; p<0,01). It was assumed that gender and grade of education might moderate digital experience. The results have shown that there are not so many differences between 3rd and 4th graders.

3rd graders significantly better recognized mobile apps associated with games (Tree cats – χ^2=4,60, p<0,05; Fiksiki – χ^2=5,03, p<0.05). At the same time, 4th graders significantly better recognized Skype icon (χ^2=4,37, p<0,05). Similarly, too few differences were found when girls and boys were compared in their recognition of mobile apps' icons. Girls significantly better identified Google Photos app's icon (χ^2=5,68, p<0,05) and Dr. Panda School app's icon (χ^2=6,65, p<0,01). On the contrary, boys were better in recognition of such mobile games apps' icons as LEGO (χ^2=11,00, p<0,01) and Minion Rush (χ^2=4,08, p<0,05).

Table 1. Icon Recognition Test: Mobile apps and results for the most identified icon (Note: *p<0.05; **p<0.01)

Mobile application	Percent identified					
	Longitudinal samples (n=155)		Total sample of 2019 year (n=235)			
			Gender		Grade	
	2018	2019	boys	girls	3rd	4th
YouTube	90,21*	96,30*	95,58	94,23	94,12	95,65
Vkontakte	81,96**	94,07**	95,58	94,23	94,12	95,65
Phone	81,44**	97,04**	94,69	97,12	97,06	94,78
Google Maps	80,41**	96,30**	94,69	95,19	94,12	95,65
Photo Camera	79,38**	88,15**	85,84	91,34	87,25	89,57
Gallery Android	77,32*	84,44*	85,84	85,58	89,22	82,61
Instagram	74,74**	93,33**	92,92	94,23	94,12	93,04
Fiksiki	73,20	70,32	69,03	71,16	77,45*	63,48*
Masha and The Bear	70,10	71,61	69,91	78,85	78,43	70,43
Google Play Music	67,01**	88,39**	92,92	85,58	92,16	86,96
Weather	63,92**	86,67**	89,38	88,46	86,27	91,30
Tree cats	62,89	64,94	58,41	68,27	70,59*	56,52*
Mult (Russian cartoon app)	62,89**	79,26**	76,11	84,62	84,31	76,52
LEGO® NINJAGO	62,37	63,70	76,99**	55,77**	68,63	65,22
Facebook	60,82**	94,04**	93,81	94,23	93,14	94,78
Minion Rush	55,15**	83,70**	85,84*	75,00*	76,47	84,35
Skype	49,48**	74,81**	76,99	75,00	69,61*	81,74*
Google Photos	46,91**	89,63**	84,07*	94,23*	86,27	91,30
Google-Play-Movies	39,18**	84,44**	87,61	81,73	88,24	81,74
Twitter	39,18**	77,78**	76,99	81,73	75,49	82,61
Monster Trucks racing game	31,96	46,67	47,79	54,81	56,86	46,09
Google drive	24,74**	80,74**	83,18	81,73	83,33	81,74
Toy Pop Cubes	19,59	25,93	32,74	31,73	31,37	33,04
Dr. Panda School	17,53**	32,59**	29,20**	46,15**	36,27	38,26
Gdz (made homework)	12,89**	28,15**	35,40	36,54	34,31	37,39

Analysis of variance revealed significant contributions of gender and grade in IRT scores, DSS and evaluation of children's engagement with DTU by teachers (see Fig. 1). Each factor affects the digital experience's parameters separately. So all the parameters of digital experience were higher in 4th graders (F=10,34; p<0,0001). However, we found a more contradictory effect of gender on parameters of digital experience (F=6,30; p<0,0001). Girls were evaluated significantly less engaged with DTU than boys by teachers, but girls had higher IRT scores than boys. At the same time, girls and boys had the similar scores in DSS.

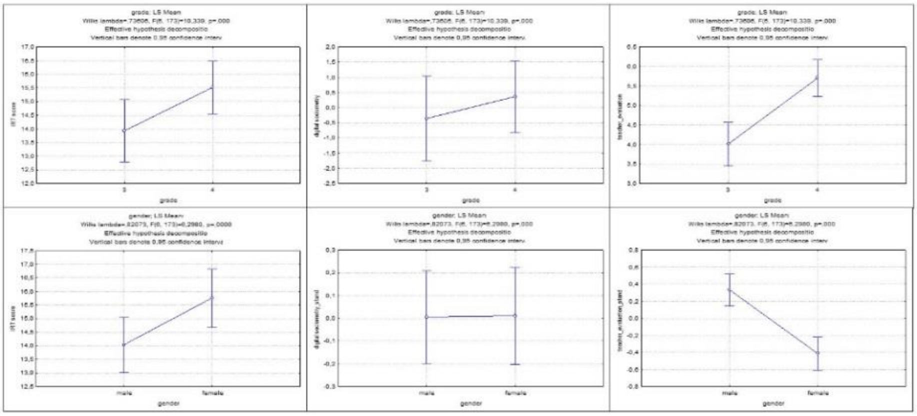

Fig. 1. Effects of gender and grade on estimation of digital experience

We also revealed significant contributions of digital experience parameters in cognition variables (see Fig.2). Children with higher IRT scores had more developed visual memory (F=2,85; p<0,05), sustained attention (F=4,42; p<0,05). They more easily disclosed causal relationships between events (F=4,04; p<0,05). Interestingly, the memory development of children who had middle DSS was higher than the rest.

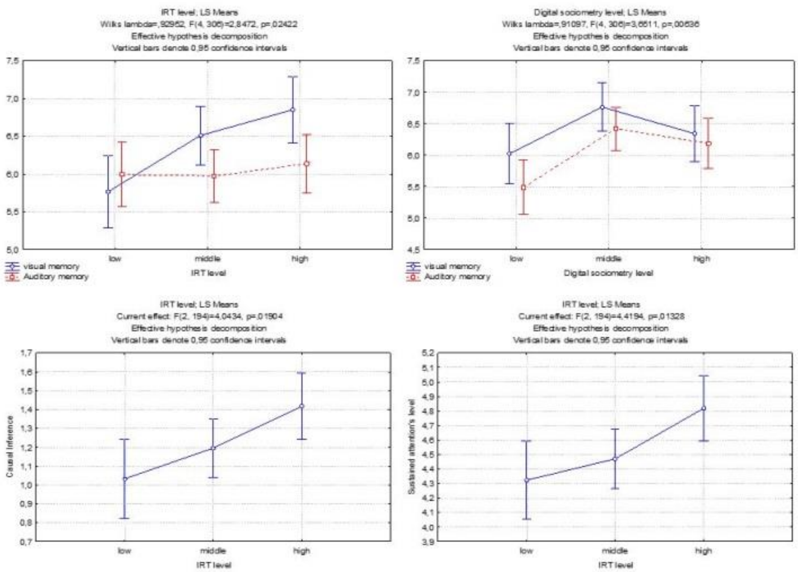

Fig. 2. Effects of digital experience on cognition

There were obtained significant correlations between IRT scores and cognition variables (see Table 2). The children who had higher visual memory skills (r=0,23, p<0,01) and higher ability to understand social situations and to draw deductive reasoning inferences (r=0,20, p<0,01) recognized mobile apps icons better. It is important to note that DSS and teachers' evaluations of children engagement with DTU didn't have any connection to cognition variables.

Table 2. Means, Standard Deviation, Correlation coefficients between IRT scores, DSS, teacher's evaluation of children's engagement in DTU and cognition's variables (Note: *p<0.05; **p<0.01)

Variables	1	2	3	4	5	6	7	8	9
1. Visual memory	-								
2. Auditory memory	$0,29^{**}$	-							
3. Generalization	-0,01	0,01	-						
4. Causal inference	$0,27^{*}$	$0,16^{*}$	0,08	-					
5. Comprehension	$0,16^{*}$	0,13	0,10	$0,16^{*}$	-				
6. Sustained attention	$0,17^{*}$	$0,25^{**}$	0,09	0,10	$0,16^{*}$	-			
7. DSS	0,07	0,14	0,06	0,06	0,12	0,03	-		-
8. TE	0,10	0,02	-0,01	0,05	-0,04	0,01	0,14	-	
9. IRT score	$0,23^{**}$	0,13	0,08	$0,20^{**}$	0,07	0,08	$0,16^{*}$	-0,02	-
Mean	6,59	5,97	3,67	1,21	5,18	1,51	-0,05	5,11	14,99
Standard deviation	1,72	1,45	0,92	0,73	1,57	1,01	6,11	2,61	5,10

The results revealed disturbingly low correlation between IRT scores and teacher's evaluation of children's engagement with DTU. But there was connection between IRT scores and DSS. The children who recognized mobile apps icons better were rated higher in DSS by other children (r=0,16, p<0,05).

Finally, we conducted analysis of variance and correlation analysis to find associations between digital experience parameters and children's learning outcomes. There wasn't significant contribution of IRT scores in average quarter grades of children (F=1,70, p>0,05). However, DSS and TE significantly contributed to average quarter grades and these contributions were opposite (See Fig.3). When children need to get advice about digital technology they seem to prefer peers who had higher learning outcomes (F=29,13, p<0,0001). When teachers evaluated children's engagement with DTU they tend to rate higher those students who had lower learning outcomes (F=4,20, p<0,05).

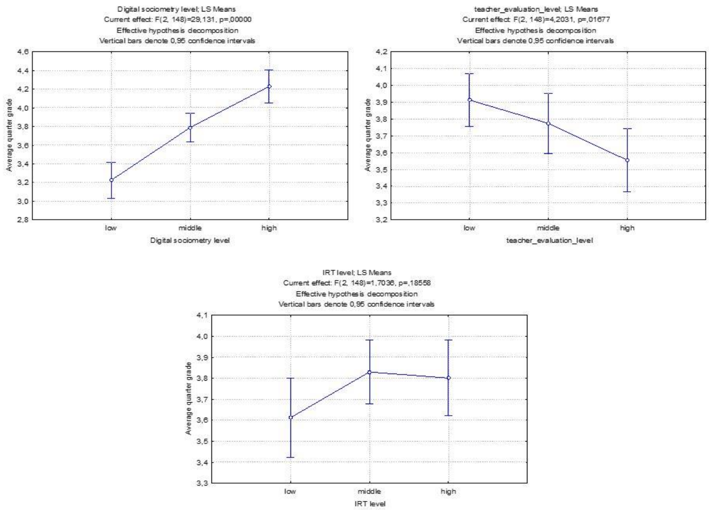

Fig. 3. Effects of digital experience on learning outcomes

Analysis of correlational matrix revealed strong associations between IRT scores; DSS and learning outcomes (see Table 3). The children who recognized mobile apps icons better had higher learning outcomes and were rated higher in their DSS.

Table 3. Means, Standard Deviation, Correlation coefficients between IRT scores, DSS, teachers' evaluations of engagement with DTU, and learning outcomes (Note: *p<0.05; **p<0.01)

Variables	1	2	3	4	5	6	7
1. IRT score	-		-				
2. DSS	0,16*	-					
3. TE	-0,02	0.14	-				
4. Reading skills	0.18*	0.41**	-0.06	-			
5. QG Language	0.19**	0.43**	-0.03	0.52**	-		
6. QG Math	0.28**	0.48**	0.02	0.56**	0.76**	-	
7. QG Reading	0.22**	0.44**	-0.08	0.62**	0.64**	0.64**	-
8. Average QG	0.26**	0.51**	-0.09	0.64**	0.90**	0.90**	0.86**
Mean	14,99	-0,05	5,11	5.41	3.49	3.68	4.22
Standard deviation	5,10	6,11	2,61	2.50	0.79	0.80	0.78

It is important to note that teachers' evaluation of children's engagement in DTU didn't have any significant correlation with children's learning outcomes.

4 Discussion

The findings of this study help to disclose some aspects of digital experience and its connections to cognitive development and learning outcomes in primary school children. The study approved hypothesis about qualitative changes in children's digital experience after one year. In just one year the landscape of the known by children mobile apps has significantly transformed and expanded. In children's minds, mobile games give way to apps whose main functions are connected to different forms of communication and media consumption. Many children have begun to own smartphones in primary school age that let them discover digital worlds more extensively and intensively. Higher DSS of 4th graders might indicate also an intensification of communication on the topic of digital technology, as children get older. Children continue to master their digital opportunities in the field of those mobile apps which are widely used by adults. The results of the study show there is a qualitative leap in the digital experience of children who hold down in their minds not only the apps that they usually use but also apps related to them (for example, Google products apps like Google Drive). Such uneven, abrupt development of children’s digital experience is confirmed by the absence of significant correlation between two points of IRT scores dimension with a gap of one year. In primary school age, none has the internal advantages of developing the digital experience even if he or she had more knowledge about mobile devices just a year before. However, adults tend to associate the digital experience with negative consequences. Their estimates do not fundamentally change throughout one year despite the qualitative transformation of the children’s digital experience. Teachers attribute higher engagement with DTU to lagging students, although this connection is not evident. Importantly, there were gender differences in estimation of children’s engagement with DTU caused by vulnerability of such estimates to social bias and gender stereotypes. So quality of estimation of children’s digital experience by adults might be equivocal that has already been doubted in previous studies [32; 35; 36; 47].

The findings of this study have shown positive connections between the digital experience and cognitive development. We revealed connection between IRT scores and visual memory skills, sustained attention, causal inference and learning outcomes of children that approved the first hypothesis. The connections between executive functions, learning outcomes, and the digital experience raise a set of psychological questions for further research as they do not correspond with some previous studies [3; 13; 19; 25; 49] but approve others [1; 11; 21; 42; 43]. It is important to study the formation of the children’s digital experience in its inseparable connection with the child mental development. G.U. Soldatova and A.E. Vishneva suggest that there may be found a golden mean for a time of Internet usage by children that could provide better support to their cognitive development [42]. The results of this study might not be approval for causal relationships between the digital experience and cognitions. We only can say that cognitive development is accompanied by enrichment of the digital experience which is its integral part in modern conditions of children’s mental development.

Conclusion

Despite of increasing expansion of digital technologies to daily children lives there are still many open issues related to children interaction with digital devices.

In this study we revealed breadth and content of children digital experience and its associations with cognitive development and learning outcomes. We found that enrichment of digital experience is embedded in children's cognitive development since it is a part of perception, exploration, and reflection of the surrounding world. Gaining knowledge about the digital world doesn't contradict but rather supports cognitive development of children. The findings of this study may serve as a framework for the development of supporting psychological programs used in processes of digitalization and personalization of elementary education. We also suppose that this study would contribute to the development of methodological discussion dedicated to questioning how to measure the experience of children with digital devices.

References

1. Athreya, B. H., & Mouza, C. Thinking Skills for the Digital Generation: The Development of Thinking and Learning in the Age of Information. Cham: Springer International Publishing. (2017).
2. Barr N, Pennycook G, Stolz JA, et al. The brain in your pocket: evidence that smartphones are used to supplant thinking. Comput Hum Behav 2015; 48: 473–480.
3. Beland, L., & Murphy, R. (2016). III Communication: Technology, distraction & student performance. Labour Economics, 41, 61-76. https://doi.org/10.1016/j.labeco.2016.04.004
4. Brogger, A., Newman, K. Persistence of vision: the interplay of vision, memory and media in contemporary art and science. In: Brogger, A. and Kholeif, O. Eds., Vision, Memory and Media. Liverpool: Liverpool University Press, pp. 13-25 (2010).
5. Buckingham, D.: After the Death of Childhood: Growing Up in the Age of Electronic Media. Polity Press, Oxford (2000).
6. Byrne, J., Kardefelt-Winther, D., Livingstone, S., Stoilova, M. Global Kids Online Research Synthesis, 2015-2016. UNICEF Office of Research Innocenti and London School of Economics and Political Science. (2016).
7. Chaudron, S. Beutel, M. E., Cernikova, M., Donoso Navarette, V., Dreier, M., Fletcher-Watson, B., ... Wölfling, K. Young Children (0–8) and Digital Technology: A Qualitative Exploratory Study across Seven Countries; Publications Office of the European Union: Luxembourg, (2015). DOI: 10.2788/00749.
8. Clark, A. Supersizing the mind: Embodiment, action, and cognitive extension. Oxford, England: Oxford University Press. (2008).
9. Cordes, C., Miller, E. (Eds.): Fool's Gold: A Critical Look at Computers in Childhood. Alliance for Childhood: College Park, MD (2000).
10. Cortesi S and Gasser U (eds) Digitally Connected: Global Perspectives on Youth and Digital Media. Harvard, MA: Berkman Center Research. (2015) DOI: 10.2139/ssrn.2585686.
11. Danovitch, J. H. Growing up with Google: How children's understanding and use of internet-based devices relates to cognitive development. Human Behavior and Emerging Technologies, 1(2), 81-90. (2019) DOI: 10.1002/hbe2.142.
12. de Souza e Silva A.: From cyber to hybrid: mobile technologies as interfaces of hybrid spaces. J. Space & Culture. 9(3), 261–278 (2006).
13. Dempsey, S., Lyons, S. and McCoy, S. Later is better: Mobile phone ownership and child academic development, evidence from a longitudinal study. Economics of Innovation and New Technology (2018).
14. Dennett, D.C.: Kinds of Minds: Towards an Understanding of Consciousness. Weidenfeld and Nicholson, London (1996).

15. Ellison, K. (2012). Are Smartphones Making Us Dumber? Available at: http://www.forbes.com/sites/netapp/2012/09/12/is-an-digital-data-overloadshortening-our-attentions-spans-and-making-us-dumber/ [accessed November 22, 2018].
16. Fajoli, A., Voiskounsky, A.E., Bogacheva, N.V. Augmented Human Beings: Developing Cyberconsciousness, Issues of philosophy, 3, 147-162, 2016.
17. Fel'dshtejn, D. I.: Glubinnye izmenenija sovremennogo Detstva i obuslovlennaja imi aktualizacija psihologo-pedagogicheskih problem razvitija obrazovanija. J. Vestnik prakticheskoj psihologii obrazovanija. 1(26), 45-54 (2011).
18. Green, C. S., & Bavelier, D. Learning, attentional control, and action video games. Current Biology, 22, 197–206. (2012).
19. Griffiths MD, Kuss DJ, King DL. Video game addiction: past, present and future. Curr Psychiatr Rev.8(4),308–318 (2012).
20. Howell, R. D., Scott, P. B., & Diamond, J. The effects of “instant” LOGO computing language on the cognitive development of very young children. Journal of Educational Computing Research, 3, 249–260 (1987). doi:10.2190/A0QKHB7A-RXQB-70NC.
21. Hsin, C.-T., Li, M.-C., & Tsai, C.-C. The Influence of Young Children’s Use of Technology on Their Learning: A Review. Educational Technology & Society, 17 (4), 85–99. (2014).
22. Internet v Rossii. — M.: Tipografiya «Forvard Print» (2018).
23. Jackson, L.A., Witt, E.A., Games, A.I., Fitzgerald, H.E., von Eye, A., Zhao, Y. (2012) Information technology use and creativity: Findings from the Children and Technology Project. Computers in Human Behavior, 28, 370– 376.
24. Johnson, G. Internet use and child development: The Techno-Microsystem/ Australian Journal of Educational & Developmental Psychology. 10, 32 - 43. (2010).
25. Kemp, N. Mobile Technology and Literacy: Effects Across Cultures, Abilities and the Lifespan. Journal of Computer Assisted Learning 27 (1), 1–3 (2011).
26. Kuhlman, J.S., Beitel, P.A.: Videogame experience: A possible explanation for differences in anticipation of coincidence. J. Perceptual and motor skills. 72(2), 483-488 (1991).
27. Livingstone, S., Haddon, L., Vincent, J., Mascheroni, G. and Ólafsson, K. Net Children Go Mobile: the UK report. London: London School of Economics and Political Science. (2014).
28. McClurg, P.A., Chaille, C.: Computer Games: Environments for Developing Spatial Cognition. J. of Educational Computing Research. 3, 95–111 (1987).
29. McEwen, R., Dubé, A. K. Understanding tablets from early childhood to adulthood: Encounters with touch technology. New York: Routledge (2017).
30. Miller, G.G., Kapel, D.E.: Can NonVerbal, Puzzle Type Microcomputer Software Affect Spatial Discrimination and Sequential Thinking of Skills of 7th and 8th Graders? J. Education. 106, 160–167 (1985).
31. Nemov, R. S. Psychology. In 3 books. B. 3.: Psychodiagnostics. Introduction to scientific psychological research with elements of mathematical statistics. Vlados, Moscow (In Russian) (2016).
32. Ogelman, H.G., Güngör, H., Körükçü, Ö., Sarkaya, H.E.: Examination of the relationship between technology use of 5–6 year-old children and their social skills and social status. J. Early child development and care (2016), http://dx.doi.org/10.1080/03004430.2016.1208190.
33. Powers, K. L., Brooks, P. J., Aldrich, N. J., Palladino, M. A., Alfieri, L. (2013). Effects of video-game play on information processing: A meta-analytic investigation. Psychonomic Bulletin & Review, 20(6), 1055–1079. doi:10.3758/s13423-013-0418-z.
34. Prensky, M. (2001), "Digital Natives, Digital Immigrants Part 1", On the Horizon, 9 (5), 1-6. https://doi.org/10.1108/10748120110424816.
35. Proekt Y., Khoroshikh V., Kosheleva A., Lugovaya V., Piskunova E. YouTube Generated: Mobile Devices Usage in Primary School Children. In: Alexandrov D., Boukhanovsky A.,

Chugunov A., Kabanov Y., Koltsova O., Musabirov I. (eds) Digital Transformation and Global Society. DTGS 2019. Communications in Computer and Information Science, vol. 1038. Springer, Cham (2019) DOI https://doi.org/10.1007/978-3-030-37858-5_51.

36. Proekt Y., Kosheleva A., Lugovaya V., Khoroshikh V. Developing Social Competence of Preschoolers in Digital Era: Gender Dimensions. In: Alexandrov D., Boukhanovsky A., Chugunov A., Kabanov Y., Koltsova O. (eds) Digital Transformation and Global Society. DTGS 2017. Communications in Computer and Information Science, vol. 745. Springer, Cham (2017) DOI: 10.1007/978-3-319-69784-0_7.
37. Psychological diagnostics of developmental disorders in primary school children. L.M. Shipitzina (Ed.). Rech, Saint-Petersburg (In Russian) (2008).
38. Sala G, Gobet F. Cognitive Training Does Not Enhance General Cognition. Trends Cogn Sci. Elsevier Ltd; 23, 9–20 (2018). https://doi.org/10.1016/j.tics.2018.10.004 PMID: 30471868.
39. Semago, N. Ya., Semago, M. M., Guide to psychological diagnostics: preschool and primary school age. Methodical manual. APKIPRO RF, Moscow (In Russian) (2000).
40. Smirnova, E.O.: Doshkol'nik v sovremennom mire. Drofa, Moskva (In Russian) (2006).
41. Soldatova G, Rasskazova E, Zotova E, Lebesheva M, Geer M and Roggendorf P Russian Kids Online: Key Findings of the EU Kids Online II Survey in Russia. Moscow: Foundation for Internet Development. (2014).
42. Soldatova G.U., Vishneva A.E. Features of the Development of the Cognitive Sphere in Children with Different Online Activities: Is There a Golden Mean? Counseling Psychology and Psychotherapy. 27 (3), 97—118 (2019) doi: 10.17759/cpp.2019270307 (In Russ., abstr. in Engl.).
43. Soldatova G.U., Vishneva A., Chigarkova S. Features of cognitive processes in different Internet activity. European Proceedings of Social and Behavioural Sciences, XLIII, 611—617. (2018) doi:10.15405/epsbs.2018.07.81.
44. Sparrow B., Liu J. Wegner D. Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips, Science, 333 (6043), 776-778 (2011) DOI: 10.1126/science.1207745.
45. Spitzer, M. Antimosg. Digital technologies and the brain. Moscow: AST (in Russian) (2014).
46. Subrahmanyam, K., Greenfield, P., Kraut, R., Gross, E. (2001). The impact of computer use on children’s and adolescents’ development. Journal of Applied Developmental Psychology, 22(1), 7–30.
47. Vandewater, E. A., Lee, S.-J. Measuring Children’s Media Use in the Digital Age: Issues and Challenges. The American Behavioral Scientist, 52(8), 1152–1176. (2009). https://doi.org/10.1177/0002764209331539.
48. Vygotsky L.S. Problemy razvitiya psihiki. In: Vygotsky L.S. Sobranie sochinenij: 6 (3) Pedagogika, Moskva (In Russian) (1983).
49. Wilmer, H, Sherman, A, Chein, J. Smartphones and cognition: A review of research exploring the links between mobile technology habits and cognitive functioning. Frontiers in Psychology, 8. 25 (2017) doi:10.3389/fpsyg.2017.00605.
50. Yasyukova L. A. The forecast and prevention of education problems in 3rd to 6th grades. Imaton, Saint-Petersburg (In Russian) (2003).
51. Yuji, H.: Computer Games and Information-Processing Skills. J. Perceptual and Motor Skills. 83, 643–647 (1996).