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# DIGITALIZATION: CURRENT CHALLENGES AND PERSPECTIVES

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## Sexting, Self-esteem, and Social Media: A Comparison among Frequent, Occasional, and Non-sexting Italian Adolescent Girls

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**Background**. The phenomenon of sexting consists of sending and sharing sexual images, videos, or messages using smartphones and social networks. Sexting is spreading dangerously among adolescents who share private and explicit sexual content, ignoring the negative and risky consequences associated with this behavior. According to recent literature, sexting behavior is strongly related to the participants' level of self-esteem and social media's influence on them.

**Objective**. Our study was a descriptive community-based study focused on the central-south[1] Italian context, which aimed to investigate sexually risky behavior and the main motivations for sexting, and to compare differences in self-esteem and social media's influence among three groups of Italian girls: non-sexters, occasional sexters, and frequent sexters.

**Design**. Our research involved 569 Italian girls (14–19 years old) who completed the following questionnaires: the Health and Sexual Behavior Questionnaire; the Sexting Behavior Scale; the Multidimensional Self-Concept Scale; and the Sociocultural Attitudes Toward Appearance Questionnaire-3.

*Keywords:*
sexting,
adolescence,
sexuality,
self-esteem,
social media

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[1]  The research was conducted in the lower Lazio, in the south centre of Italy

**Results**. Our results showed that most participants sexted with their partner, and had a responsible attitude toward sexuality and kept sexual risk low. Moreover, frequent sexters had higher scores on social media's influence relative to the internalization of the body image and model for beauty and athleticism, as well as lower levels of global, academic, and competence self-esteem.

**Conclusion.** Our results could promote interventions in the school context in order to: a) improve awareness among youth about social media use, sexting, and safe sexuality; b) reduce the risk associated with sexting and the influence of social networks; and c) stimulate reflections by teachers and parents on adolescents' sense of identity and self-esteem.

## Introduction

### Sexting: Theoretical frameworks

Teenagers' daily lives are becoming more and more impacted by social media, continual connectedness, and virtual contact on the Internet and mobile devices. In this setting, intimate communication need not occur exclusively face-to-face, but also through various electronic media, including phone conversations, emails, texts, images, and videos.

The current discussion of adolescent sexting in both academic and popular circles has raised several concerns about how to reduce the negative psychological and legal consequences of this activity, and support adolescents' sexual health and empowerment. Indeed, sexting — defined as the exchange of messages, videos, and photos with explicit sexual content through Smartphone applications (Semenzin & Bainotti, 2020; Ojeda et al., 2020; Campelli, 2021) — is commonly considered one of the main risks derived from the development of new technologies and social networks among teens (Saladino et al., 2020). In most cases, youth who sext are unaware of the possible negative consequences of this activity, including the risks of cyberbullying, blackmail, sexual violence, cyberstalking, revenge porn, sextortion, grooming, Pull a Pig, and suicide (Scherr, 2022; Hu, Clancy, & Klettke, 2023). Thus, sexting can lead to harmful outcomes and involve risks for the adolescent's development (Cuccì et al., 2023).

In the Italian context, according to the National Observatory on Adolescents (2018), teens exchange intimate selfies — without clothes or with a sexual background with one's partner — to friends in group chats without a real awareness of the possible consequences. From one online survey, it emerged that sexting is a practice routinely used by 6% of preteens age 11 to 13, of which seven out of 10 are girls. The numbers rise between the ages of 14–19. Indeed, one out of 10 adolescents sends sexually explicit content online. Girls are more at risk and are often also victims of revenge porn and cyberbullying derived from sexting, considering that 33% of the episodes of digital bullying are of a sexual nature. Along the same line, data from the Italian Federation of Scientific Sexology (FISS) has reported that 48% of adolescents practice sexting (Belli & Galletti, 2019).

Moreover, Migliorato et al. (2018) found that adolescents who engage in sexting have a lower perception of risk in their behavior and are more likely to drink, smoke,

and engage in unprotected sex. This aspect could be associated with the tendency of adolescents to explore new situations and contexts in their attempts to define their autonomy and identity, while often not perceiving related risks (Saladino et al., 2020).

The negative narrative around sexting has occurred at the same time that the phenomenon seems to have become more normalized. Indeed, Mori et al. (2021) recently found that juvenile sexting is increasingly widespread compared to the past. This finding leads to the possible interpretation that early adolescents are exploring their sexuality in a protected context. From this standpoint, as posited by the concept of Positive Youth Development (Pistoni et al., 2023), sexting can be conceptualized as the modern manner that adolescents express their sexuality in the digital age (Yépez-Tito et al., 2020), as well as in intimate communication facilitated by technology.

Studies on how gender and sex correlate with sexting have found that girls are more likely than boys to be affected by peer pressure to engage in sexting behavior due to the fear of losing their partner (Van Ouytsel et al., 2017). In addition, sexting appears to be on the rise for those between adolescence and emerging adulthood (Choi et al., 2019).

A review of the literature shows the necessity of researchers promoting recommendations for caregivers and teachers to use in stimulating their children/students to think critically and to reflect on the consequences of their actions. This would include promoting more disclosure to adults and decreasing severe risks to the adolescents' identity and autonomy within a positive developmental framework, thus enhancing the strengths and supporting the sexual well-being of young people in the digital age.

### *The current research:*
### *Descriptive community-based study, goals, and hypothesis*

Our study was a descriptive and community-based contribution focused on a sample of girls from the central-south area of Italy. We intended to draw attention to the phenomenon in a poorly explored context such as the central-south, with a sample exposed to the consequences of sexting, *i.e.*, girls. Our study aimed to explore sexting behavior with the following goals: a) describe the propensity of the sample to sext and their related motivations; and b) compare differences in self-esteem and the influence of social media among three groups of Italian girls, grouped according to their attitudes toward sexting behavior (non-sexters, occasional, and frequent).

We framed the following hypotheses: (H1) Participants who sext occasionally and frequently are more exposed to high-risk sexual behaviors; (H2a) Those who sext occasionally and frequently are more influenced by social media; and (H2b) Sexters have a lower level of self-esteem than those who do not sext. To the best of our knowledge, data on these questions are not currently available in the literature, and thus our study could contribute new knowledge on the subject.

Indeed, sexting spreads in several contexts and could have different motivations. Moreover, although sexting is a well-known and widespread phenomenon, there are poorly explored areas, such as the central-south of Italy, where there is a gap in the awareness about sexting-related sexual and developmental risks, especially among

girls, who seems to be more affected by the consequences of this phenomenon. This gap could be related to a lack of sex education by the local institutions and families in sexual education. For this reason, our main aim was to investigate the frequency of sexting and its relationship with self-esteem and social media's influence in this specific social group.

### Social media and body image among sexting girls

During adolescence, individuals develop a sense of autonomy and a personal perception of themselves based on external judgments and pressures derived from their social context, peer group, and social media (Eleuteri & Saladino, 2023).

Social media — such as television, magazines, website, and social networks — and social comparisons greatly influence our perception of our body image and promote an ideal of beauty which often leads to body dissatisfaction (Verrastro et al., 2020) and risky behavior (Eleuteri & Saladino, 2023). According to the literature, girls seem more affected by social media exposure on questions related to aesthetical values and body satisfaction.

For instance, the Public Use Microdata Files of the Canadian Community Health Survey (Statistics Canada, 2012; Carter et al., 2017) involved 130,000 Canadian girls (12–29 years) in investigating the association between their body dissatisfaction and amount of time online. They found that participants who spent more than 20 hours per week online (especially girls 11-, 13-, and 15-year-old) showed higher levels of body dissatisfaction than the group with the least Internet use (none/ < 1 hour). According to the authors, time spent online leads to higher exposure to the sociocultural influences that confirm the importance of the beautiful physical appearance as a central component of a girl's identity. This exposure could be linked to the internalization of an unattained female beauty model and thus increased body dissatisfaction (Speno & Aubrey, 2019).

Sexting girls might aspire to achieve the perfect appearance proposed by social media, and search for gratification about their body image, due to their internalization of proposed models. This idealization produces a conflict, leading to lower body satisfaction (Dully et al., 2023). Mostly, girls tend to manipulate their pictures by presenting themselves as perfect and beautiful, and the more they modify the images offered on the web, the more they lose the ability to interpret reality about their aesthetic identity and that of others, basing themselves only on social comparisons.

This interpretation is consistent with the study by Kleemans et al. (2018), who investigated the negative effect on the body image of manipulated Instagram* photos, and the role played by the tendency to rely on social comparison. The authors randomly exposed 72 girls of 14–18 years to 10 original Instagram* photos, and 72 girls of the same age to 10 manipulated Instagram* photos. The results showed that the group exposed to manipulated photos reported lower body satisfaction, especially among girls with a higher tendency to rely on social comparison. Thus, social comparison mediates the perception of body image, leading girls to manipulate their photos to be accepted by the community, and thus feel less discomfort toward their bodies.

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\* — Activities of Meta Platforms Inc. (Facebook and Instagram), and the X Corp. (as the successor of Twitter Inc.), are prohibited in the Russian Federation.

Mostly, girls with a higher tendency to rely on social comparisons do not notice that pictures are reshaped or manipulated, thinking that they are real because of their systematic exposure to the ideal of beauty. Moreover, sexting girls seem to be more sensitive to this exposure due to the goal of their pictures. For example, girls of 6-7 years post explicit sexual videos on the video-sharing app musical.ly and manipulate and retouch them, imitating their popular models and developing an obsession about their appearance and sexualization (Rondino, 2018).

Thus, this focus on the ideal body and the perception of aesthetical satisfaction impact sexual development and can increase the possibility of sexting. Howard et al. (2019) investigated this connection and found that the group with a negative perception of their appearance reported feeling higher pressure to sext, because in sending and receiving sexts, their body dissatisfaction decreased. This phenomenon could potentially represent a rewarding experience for sexters, who are more vulnerable to being victimized through coercion or manipulation due to their external motivation in doing sexting and in being more exposed to other comments. Bianchi et al. (2017) confirmed these results, finding that people who compare their bodies to the cultural and social standard of beauty are more likely to sext in order to receive positive reinforcement.

Based on the cited results, our study aimed to elaborate on the hypothesized association between the frequency of sexting, the attitude toward sexting, social media's influence on the internalization of the sexters' aesthetic values, and the self-esteem of the specific target group.

### Self-esteem, sexting related motivations, and sexuality

Self-esteem is a socio-psychological construct derived from social interactions. Individuals develop self-esteem through interpersonal relationships from childhood to adulthood, experimenting with different contexts and roles. Teens are more likely to be influenced by peers in developing their sense of self-esteem, according to the scientific evidence (Antonopoulou, Chaidemenou, & Kouvava, 2019). One of the most emphasized concepts in studies of self-esteem among youth is their need to belong to a group and the influence that low self-esteem has on some risky behaviors, such as substance abuse, sexually risky behavior, problematic internet and social media use, and sexting (Wang et al., 2017; Saladino et al., 2020).

For the most part, adolescents with low self-esteem experience a feeling of inferiority, self-dissatisfaction, and a higher need for peer approval. Specifically, regarding body perception and sexting, research has shown that those less satisfied with their body and less confident in emotional and sexual relationships tend to sext in order to receive social gratification (Howard et al., 2019; Howard et al., 2021).

In line with these results, Wachs et al. (2017) highlighted in their study that increased self-esteem and self-control lead to decreased sexting.

This result seems to be more evident among adolescents than adults. Indeed, there are no differences in the level of sexting (non-sexters, sexters who send and receive, and sexters who receive), and the levels of self-esteem among young adults (Sharma et al., 2019). One possible explanation is related to the lower need for approval and the different impact of social media among adults, who have already developed their

sense of identity, and often use sexting within their intimate relationship, and are more aware of the consequences (Jeanfreau et al., 2019).

Thus, self-esteem plays a protective role in sexting, and in lessening the influence of social media, especially among adolescents with lower self-esteem, who are more sensitive to the aesthetical ideal and the information provided by media (Dully et al., 2023). Indeed, sexting is associated with the desire to be perceived as beautiful and popular (Eleuteri et al., 2017). Many teens have not experienced sexual intercourse and are afraid because they feel uncomfortable with their aesthetical aspect. Online contact, mediated by technological devices, can increase self-awareness and security (Howard et al., 2019). Sexting might be the first approach to sexuality among many adolescents or a part of a couple's sexuality (Kosenko et al., 2017).

From this standpoint, the association between sexting and sexual risks is not linear. Indeed, Davis et al. (2016) see motivations for sexting as a way of discriminating between healthy sexual enrichment within a stable relationship, and a way to captivate new and casual partners, an attitude that may affect sexual health.

Moreover, some individuals sext for intra-individual motivations, such as exploring sexuality, flirting, or having fun (Bianchi et al., 2016, 2017), sexual empowerment, or personal expression (Liong & Cheng, 2019); other individuals sext for extra-individual motivations, such as looking for positive reinforcement for their body image and drawing attention to themselves. Most individuals seem to sext for extra-individual reasons (Bianchi et al., 2016), especially to receive feedback on their aesthetical aspect; this leads to negative consequences.

We were interested in investigating sexting-related motivations — analyzed qualitatively and descriptively in our protocol — in addition to the relationship between self-esteem and the influence of social media on the frequency of sexting. Although evaluating reasons for sexting was not the focus of our work, the literature indicates that motivation affects the greater or lesser probability of risks associated with sexuality.

## Methods and Measurements

### Participants

Our sample was composed of 569 girls (mean age = 16.93; SD = 1.375; age range: 14–19) recruited from high schools in the central-south area of Italy.

The researchers explained the aims and scope of the research to the adolescents and their parents, and obtained informed consent signed by the parents, and authorization from the school Director. The study was conducted following the standards set by the Declaration of Helsinki and was approved by the Institutional Review Board of the University of Cassino and Southern Lazio (Italy).

### Procedures

The questionnaires were administered during regular school hours under the supervision of the teachers and the research team. This process took approximately 60 minutes. The participants were informed of the complete anonymity of the information they were about to provide. Participants were aware that they could stop completing the questionnaires at any time and request that their data not be used.

### Measurements

*The Questionnaire on Health and Sexual Behavior* (University of Cassino and Southern Lazio) is a self-report developed for this study by the University of Cassino and Southern Lazio research team. The questionnaire is composed of eight dichotomous items which explore aspects of sexual behavior (sexual intercourse, age of sexual intercourse, relationship status, information on contraception, morning-after pill use, sexually transmitted diseases, pregnancies, and abortions). This questionnaire aims to collect general data on sexual behavior to explore adolescent sexual awareness and experience.

*The Sexting Behavior Scale* (SBS) (Dir et al., 2013; Morelli et al., 2016) is a self-report tool which investigates the presence or absence of sexting activities and the motivations related to it. The first part contains eight items on a 5-point Likert scale, which measure the frequency of sexting behavior and the means used (*e.g.*, How often have you sent erotic images via Facebook*?). The second part aims to identify the reasons and the risk factors associated with sexting (*e.g.*, I practice sexting when I use alcohol; I practice sexting because I want to have sex). The questionnaire has a Cronbach alpha ranging from .80 to .89.

*The Multidimensional Self-Concept Scale* (Bracken & Howell, 1991; Bracken, 2003) is a self-report characterized by 150 items which assess self-concept and self-esteem on a 4-point Likert scale in six categories: 1) social (interpersonal relationships); 2) academic (school perceived success); 3) affect (emotionality); 4) family (familial relationships); 5) physical (body image); and 6) competence (control over one's environment). A lower score indicates lower self-esteem. The questionnaire has a Cronbach alpha ranging from .70 to .80.

*The SATAQ-3-Sociocultural Attitudes Towards Appearance Questionnaire-3* (Thompson et al., 2004; Stefanile et al. 2011) is a self-report tool which measures the influence of society and the media on body perception and self-image. It is composed of 30 items, evaluated on a 4-point Likert scale, divided into four subscales: 1) general internalization of the body and beauty proposed by the media (Internalization-General); 2) internalization of an athletic physical model (Internalization-Athlete); 3) pressures from the outside to coincide with the stereotype (Pressures); and 4) perception of the media as a credible and essential source of information regarding fashion and beauty (Information). High scores indicate greater adherence to the stereotype. The questionnaire has a Cronbach alpha ranging from .80 to .89.

### Statistical Analysis

The data were analyzed using the Statistical Package for Social Sciences (Version 26.0, SPSS Inc., Armonk) (IBM Corp. Released, 2019).

Descriptive analysis was used to show the youth's attitudes toward the use of contraceptive methods, the risks associated with sexuality, their main motivation, and the context of sexting behavior of the sample.

One-way ANOVAs were used with Fisher post-hoc tests to examine differences among the three groups of girls in self-esteem and social media influence.

Cohen's d effect size (ES) was utilized to calculate the magnitude of the differences among groups.

The sample was divided according to the girls' attitudes toward sexting, based on their scores on the Sexting Behavior Scale (SBS) (Dir et al., 2013; Morelli et al. 2016). The questionnaire has a minimum score of 8 and a maximum of 40. According to the point distributions identified by the authors (Dir et al., 2013) and to the distribution used by Verrastro et al. (2017), minimum, medium, and maximum scores were identified, establishing three different paths of behavior: no sexting (8 points); occasional sexting (9-12 points); and frequent sexting (>13 points).

## Results

### *Participants' profile*

Our sample was composed of 71.5% sexters, of whom 37.8% sexted occasionally and 33.7% sexted frequently.

When we evaluated the group of participants who sext regarding their attitude towards sexuality, 57.5% said they had had sexual intercourse, and 56.4% did not use contraceptive methods. Moreover, 92.2% of the sample did not use the morning-after pill. According to these results, on one hand, it seems that the girls ignored the risks associated with unprotected sexual intercourse and tend to engage in sexual intercourse.

However, these results should be interpreted in light of the girls' attitudes toward sexting and their related motivations (as reported in *Table 1*). Indeed, most of the participants sexted with their partner with the aim of engaging in a physical sexual relationship. Although most of them did not use contraceptives, or were not fully aware of the risks associated with their behavior, 99.5% never referred to having contracted sexually transmitted infections; never had to go through a pregnancy (98.3%); and had not ever voluntarily terminated a pregnancy (99.3%). These results confirm a flexible interpretation relative to sexual risks and sexting (see Discussion).

**Table 1**

*Motivation and context of sexting behavior among participants*

| Question | Answer | Percentage |
| --- | --- | --- |
| Who do you sext with? | Partner | 74.4% |
| When do you sext? | When I am at home | 24.7% |
| Why do you sext? | I would like to have sex | 45% |

### *Sexting, social media, and self-esteem: differences among girls*

We have conducted two one-way ANOVAs with Fisher's LSD post-hoc tests to compare the three groups of participants (non-sexters, occasional sexters, and frequent sexters) on the degree to which they were influenced by social media (*Table 2*) and on their self-esteem (*Table 3*).

*Table 2* shows the means and standard deviations of the first ANOVA. Regarding social media influence, there were significant differences between the three groups on the following subscales: Internalization-General, Internalization-Athlete, and Information.

**Table 2**

*ANOVA on social media and sexting variable between three groups, mean and standard deviations*

|  | Group | | | *p* | *F*-value |
|---|---|---|---|---|---|
|  | **Non-sexters** | **Occasional sexters** | **Frequent sexters** | | |
| Intern-General | 22.51(5.55) | 24.72(8.13) | 26.38(8.70) | < .001 | 9.74 |
| Intern-Athlete | 12.24(3.48) | 12.31(3.61) | 13.25(3.95) | .020 | 3.95 |
| Pressures | 20.88(2.75) | 21.02(2.14) | 21.02(2.21) | .832 | .184 |
| Information | 25.30(5.83) | 26.56(5.80) | 27.41(6.53) | .006 | 5.09 |

The Fisher's LSD post-hoc test revealed a significant difference between the first and third group of participants on Internalization-General ($p < .001$; ES = 0.530), Internalization-Athlete ($p = .047$; ES = .271), and Information ($p = .005$; ES = 0.341), and between the second and third group on Internalization-Athlete ($p = .046$; ES = 0.248), while no differences were found for Pressures.

**Table 3**

*ANOVA on self-esteem and sexting variable between three groups, mean and standard deviation*

|  | Group | | | *p* | *F*-value |
|---|---|---|---|---|---|
|  | **Non-sexters** | **Occasional sexters** | **Frequent sexters** | | |
| Social | 72.26(8.63) | 72.23 (9.29) | 71.77(11.34) | .871 | .138 |
| Academic | 68.57(6.72) | 67.34(7.14) | 65.94(7.07) | .002 | 6.23 |
| Affect | 64.62(3.88) | 64.90(3.94) | 64.13(4.27) | .159 | 1.84 |
| Family | 60.83(2.72) | 61.25(3.07) | 61.24(3.16) | .353 | 1.04 |
| Physical | 32.50(3.17) | 32.15(3.08) | 32.77(2.83) | .123 | 2.10 |
| Competence | 69.10(7.35) | 68.56(8.09) | 67.02(8.28) | .042 | 3.18 |
| Global score | 368.53(18.26) | 366.34(20.39) | 362.60(22.03) | .038 | 3.28 |

*Table 3* shows the means and standard deviations of the second one-way ANOVA regarding global self-esteem and its six sub-scores — social, academic, affect, family, physical, and competence. There is a statistically significant difference between these groups in the academic area, competence area, and in global self-esteem. A Fisher's

LSD post-hoc test revealed a significant difference between the first and the third group of participants ($p < .001$; ES = .381) on the global score, the second and the third group in academic area ($p = .044$; ES = .197), and the first and the third group of participants in competence area ($p = .017$; ES = 0.266). Moreover, global self-esteem differed between the first and the third group ($p = .012$; ES = .293).

## Discussion

### *Principal findings*

Our study aimed to analyze the phenomenon of sexting in a group of Italian teenage girls (14-19 years). Self-esteem and the influence of social media have been examined as variables that could be related to sexting behavior. The sample was divided into three groups, according to their involvement with sexting: frequent, occasional, and non-sexters. A total of 71.5% of the participants sexted, of which 37.8% sexted occasionally and 33.7% sexted frequently.

From the descriptive analysis, we found that most of the participants who sexted had had sexual intercourse (57.5%) and did not use contraceptive methods (56.4%). In our sample, the girls tended to sext with their partners when they were at home due to the desire to engage in sexual intercourse, thus showing an intra-individual motivation (Bianchi et al., 2016, 2017; Dir et al., 2013). According to some studies, intra-individual reasons for sexting protect individuals from negative consequences related to sexual risks (Souza & Lordello, 2020; Morelli et al., 2016).

Most participants reported having no sexually transmitted venereal diseases, pregnancies, or pregnancy interruptions. These results partially disconfirm our hypothesis, according to which sexters would have a higher percentage of high-risk sexual behavior (H1). However, they are in line with the literature (Dir et al., 2013; Davis, et al., 2016; Bianchi et al., 2016, 2017; Liong & Cheng, 2019). Indeed, according to the framework of the Positive Youth Development Approach (PYD) and to the recent perception of sexting as a path of behavior which describes adolescents' development, youths could explore their sexuality through sexting and improve their understanding of their feelings related to their body image (Pistoni et al., 2023), using sexting to approach sexuality for the first time, or to explore their sexuality within their relationship (Kosenko et al., 2017).

Regarding hypothesis two (H2a), our results showed significant differences between the groups, especially between frequent sexters and the non-sexting group, on the influence of social media. Frequent sexters showed higher levels of social media's influence relative to the subscales of the internalization of the body and beauty images proposed by social media (Internalization-General), the internalization of the athletic model (Internalization-Athlete), and the perception of the media as a credible and essential source of information regarding fashion and beauty (Information). These results confirm our hypothesis and are in line with recent literature.

We know from scientific evidence that social media have a higher influence on girls' perception of their bodies (Saladino et al., 2020) and sexual identity (Eleuteri et al., 2017, Verrastro et al., 2017) than on boys. Indeed, girls develop body dissatisfaction due to social comparison with the ideal of beauty and athletic models proposed by television, magazine, and social networks (Tamarit et al., 2021). During the last

few years, sexting has become one of the most widespread ways of exploring sexuality, and adolescents spend an increased amount of time online.

Increased time online leads to higher exposure to sociocultural influences related to female esthetical values and the internalization of female beauty models (Speno & Aubrey, 2019). Websites, social networks, and all online news represent a credible source of information for teens (Rawat et al., 2020), who often avoid asking for advice or communicating with adults, and prefer to rely on websites and social networks to satisfy their needs and address their questions on how to lose weight, how sexuality works, and which are the most popular beauty and fashion models (Carter et al., 2017). In particular, girls are more exposed than boys to the influence of social media and manipulated photos which represent a distortion of reality, provoking a constant comparison with pictures of "perfect" bodies, and a general discomfort with their own (Van Ouytsel et al., 2017).

Moreover, this content is often explicitly sexual and tends to objectify the female body. An example could be musical.ly, a platform used most by girls from 6-7 years to watch explicit sexual videos, imitating popular models (Rondino, 2018). However, we found no differences between the three groups in the pressure from the outside to coincide with the stereotype (Pressures). This result is controversial since it contrasts with the literature's emphasis on the role of pressure from peers and social media in promoting sexting (Barrense-Dias et al., 2017; van Oosten & Vandenbosch, 2017).

The tendency to sext is also related to the sexters' level of self-esteem. Our results underlined differences between the frequent sexter and non-sexter groups in their global self-esteem score. Frequent sexters showed lower global self-esteem, in line with recent literature. Adolescents with low self-esteem could have a lower self-satisfaction and confidence in a sexual relationship. Thus, they could be more likely to use sexting to compensate for their need for approval, to explore their sexuality mediated by a screen or to receive social gratification (Howard et al. 2019; Howard et al., 2021). Self-esteem has a protective role, especially among vulnerable teens, vis-a-vis social media's influence and sexting. Our sample seemed to show that girls sext for a personal motivation related to the desire to engage in a sexual intercourse with their partner. This aspect could indicate that they could be less at risk of the negative consequences of sexting due to the exclusive relationship with their partner. However, longitudinal studies are needed to evaluate and monitor the long-term impact of sexting. One less studied aspect is the influence of sexting behavior on self-esteem relative to other spheres of an individual's life, such as those investigated by the Multidimensional Self-Concept Scale (Bracken & Howell, 1991; Bracken, 2003). This scale is a self-report that assesses self-esteem in six areas: 1) social (interpersonal relationships); 2) academic (school perceived success); 3) affect (emotionality); 4) family (familial relationships); 5) physical (body image); and 6) competence (control over the environment).

Previous research (Wachs et al., 2017) investigated global self-esteem only. To fill in this gap, we focused on more than one area and got unexpected results: the differences between non-sexters and frequent sexter groups in self-esteem were related to the academic and competence dimensions. In addition to their lower level of global self-esteem, the frequent sexter group reported lower academic and competence self-esteem. Academic self-esteem is associated with a positive perception of one's self,

school success, and relationships with classmates (Zheng et al., 2020). Indeed, students with a good perception of themselves are more likely to achieve competence and obtain better test scores at school. Also, during adolescence, individuals typically base their self-esteem and behavior on external judgments and pressures derived from their social context, peer group, and social media (Eleuteri et al., 2017). School is a social environment in which to establish relationships, develop perceptions of themselves and others, and learn such behaviors.

Similarly, the sense of competence can be associated with agency, the perception one can deal effectively with events to control the environment and feel appreciated by others. Sexting for some individuals is a way to affirm their identity and empowerment (Liong & Cheng, 2019). During adolescence, the sense of self-confidence generally derives from others' feedback, and often youth feel unable to manage their lives. This feeling can lead them to create an idealized image that makes them feel more powerful, such as sexualized photos, which increase their social gratification (Howard et al., 2019).

Another aspect is the importance of self-esteem as related to body image; however, this was not significant in our sample. According to the literature, low self-esteem is associated with body self-esteem issues and an increased susceptibility to influence by social media platforms (Peris et al., 2019), due to adolescents' need to receive validation to compensate for their low body satisfaction; they thus become more vulnerable online (Longobardi et al., 2021).

These findings need to be thoroughly researched in the future, in order to investigate sexters' self-esteem in the academic and competence areas, and to evaluate the crucial role of body self-esteem in social media influence and sexting behavior.

## Conclusion

Our study aimed to explore the possible relationship between self-esteem and the influence of social media in an seldom-study sample, girls of the central south of Italy. The results are not generalizable due to the research design and the limited number of the participants. However, the data provide some insights into the relationship between sexting and its motivation, and on the role of self-esteem in the relationship between sexting frequency and social media influence.

This study suggested that sexting could be a way for couples to explore their sexuality or to establish sexual empowerment and identity in teens. The relationship with a partner, intra-individual motivations, and high self-esteem are possible protective factors against the negative consequences of sexting.

Thus, the most relevant aspect to consider is the sexter's self-awareness and the real motivations for their behavior. Adolescents who sext in order to receive social gratification are more likely to experience body dissatisfaction and be negatively affected by the ideal of beauty and perfection on social media. They can also be victims of sexual coercion, sextortion, cyberbullying, cyberstalking, and sexual harassment. On the other hand, sexting used with more awareness could reduce developmental and sexual risks. This approach, in line with the recent studies and reviews on the topic, challenges the conclusion that the sexting phenomenon is solely negative, perceiving it as a behavior which, if carried out in a consensual manner and without

harmful intent, might be a component of an individual's healthy relational and sexual life.

These results provided suggestions for future elaboration on the individual, educational, familial, and environmental levels. For instance, one recommendation for clinicians could be an evaluation of Italian girls' awareness of the possible consequences and risks associated with sexting as part of sexual education programs in the schools, which are not promoted in Italy, as they should be. Moreover, data on social media's influence and impact on girls' self-esteem could be used for support of teens and parents (Gugliandolo et al., 2019), deepening the role of academic success and competence in the environment and informing them about a safer use of social media and sexting.

Furthermore, there are some key points to investigate, such as the study of motivations related to sexting; the long-term sexual and behavioral effects of sexting; the extension of the research to a male sample, considering the types of sexters, those who send, those who receive, those who send and receive photos, videos or messages; the investigation of the connection between self-esteem and social media's influence; and the study of the possible mediating role of self-esteem in choosing to sext.

Finally, actions are needed at policy levels to ensure that websites and social networks convey more realistic and healthy values that inspire girls and young women to take care of themselves and not to search for unrealistic perfection, by promoting different and more realistic representations of the female aesthetic model.

## Limitations

One of the limitations of this study was the failure to investigate such factors as the youth's level of communication, family climate, parental attachment, and relationship with peers, all of which can impact youth behavior. As reported by some research on this topic (Punyanunt-Carter, 2008; Gumede et al., 2017; Haverfield & Theiss, 2017) a positive relationship with parents and belonging to a supportive peer group can protect young people from the consequences of risky behavior, including sexting (Campbell & Park, 2014; Bianchi et al., 2019; Burén et al., 2021).

A second limitation concerns the sole focus on a female sample; a deeper investigation of boys' behavior relative to sexting is needed, as there is little research on it, especially among Italians. Moreover, it is not possible to determine the direction of causality due to the descriptive and cross-sectional design we used to carry out the research. Our data collection was based exclusively on the use of self-report, thus increasing the interpretation bias of the results. Finally, the classification of the three groups of sexters was based on a scale. Therefore, future studies should consider a longitudinal design with mixed methods to increase the accuracy of the results.

## Ethics Statement

The present study adhered to the ethical guidelines outlined by the Helsinki Declaration and the Italian Association of Psychology (AIP) and was approved by the Institutional Review Board of the Institute for the Study of Psychotherapy, School of

Specialization in Strategic Approach Brief Psychotherapies (approval number: ISP-IRB-2019-1). Only participants whose parents provided informed consent were included in the study, and participation was voluntary and uncompensated. Throughout all stages of the study, participants' privacy was ensured.

## Informed Consent from the Participants' Legal Guardians (if the participants were minors)

Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## Author Contributions

V.S. and V.V. conceived of the idea, S.E. developed the theory, N.B. performed the computations, and F.C verified the analytical methods. All authors discussed the results and contributed to the final manuscript.

## Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# "Interstellar Wanderers:" Digital Support for Teaching Place Value Within the Activity Approach Framework

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**Background**. The majority of mistakes students make while using "well-learned" decimal counting, can be attributed to their miscomprehension of the structure and arrangement of the "positional" numeral system. Digital support may merely serve an illustrative and training function, or it may provide the special environment for locating the problem of positional counting as a part of meaningful actions by the students. Following the Activity approach, we aimed to scaffold the students' own learning actions, in such a way as to reveal the origin of the multi-digit number concept. Thus, we used counting in other-base systems as a way for students to reconsider the reasoning behind familiar operations in the most common base-ten system.

**Objective**. The purpose of this paper is to present the approach to computer support which we have designed, based on our analysis of the activity content related to the multi-digit number concept, and to discuss some preliminary results of the first training series.

**Design**. The approach to educational environment design developed within the Learning Activity theory defines the ways in which a computer becomes essential. The computer should provide a transparent interface which allows students to perform transformations with objects which will react accordingly. The additional opportunities to perform concept-mediated orientation procedures should also be scaffolded by digital means. For the purposes of our study, the computer-based educational module "Interstellar wanderers" was designed. Four groups of students from 2nd to 5th grade (8-12 years of age, 20 children in total) participated in the experimental computer-based lessons (over 30 hours); classroom observations, videotaped discussions, and logs of students' individual work in the computer simulation were used for analysis.

**Results**. The preliminary results of the experimental teaching showed that the computer support which we developed may scaffold students' progress toward acquisition of the multi-digit number concept through a reflective re-thinking of the well-learned decimal system. Yet further research is needed to get a quantitative analysis of students' performance.

*Keywords:* concept acquisition, orientation procedures, computer support, positional counting, multi-digit number, place value.

**Conclusion**. The general principles of computer support design based on the Activity approach in education (Galperin, Davydov, & Talyzina) demand a thorough analysis of the origin of the concept being studied, as well as the design of appropriate content and means of students' actions and corresponding contexts and tasks. The digital means which we designed to support students' learning activity, are in demand and bring promising results.

## Introduction

The place value concept is fundamental for mastering mathematics: it stands for the rationality of arithmetic operations with multi-digit numbers (Moeller et al., 2011). Even those primary school students who can already count up to 100 experience difficulties with the digit structure of numbers (Fuson, 1990; Kamii & Joseph, 1988; Thompson, 2000). "Positional" counting in the primary school years is often taught with a memorable "rhyme," used for one-by-one naming of some counted units, and accompanied by the children's rhythmical movements (hopping, going up and down the stairs, etc.). The children do not comprehend the part-whole relations of the "denominals" behind naming the numerals: the "2" in "25" is not perceived as 20, although the counting materials can be enumerated correctly (Ross, 1985).

Researchers have distinguished various stages of children's comprehension of place value as they can be assessed throughout the primary school grades, and analyzed the difficulties which students experience on the way (Fuson, 1990; Lengnink & Schlimm, 2010; Ross, 1985). Understanding the place value concept is known to be predictive of the overall mastery of mathematics (Desoete, 2015), and thus, the development of feasible ways to support students' comprehension is an urgent problem. There are researchers who focus on transcoding issues between the symbols and naming of multi-digit numbers in different languages (Hewitt & Alajmi, 2023) and on "number sense" in general (Siegler, 2016; Tikhomirova & Malykh, 2021). The central feature of their instruction theories, however, is the necessity of "bundling" (Lengnink & Schlimm, 2010; MacDonald, 1972; Mix et al., 2019), which directly reflects the composition of the multi-digit number. The preliminary introduction of the place value concept is mostly limited to two-digit numbers: the relationship between "ones" and "tens" are examined in detail, including the special operations of "trades" or "carries" needed for subtraction and addition, and then transferred to other digits (hundreds, thousands, etc.).

Different visual aids to "boost" students' understanding the place value concept are used widely, and their character and effectiveness are considered in many studies (Fuson & Briars, 1990; Herzog et al., 2019; Lafay et al., 2023; Mix et al., 2019). The most popular content among the various computer support designs for teaching about place value and operations with multi-digit numbers, is vivid illustration of separate objects grouped by tens (hundreds, thousands) in the decimal system[1]

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[1]    Some examples of internet sources:
       https://www.topmarks.co.uk/maths-games/7-11-years/place-value
       https://ictgames.com/mobilePage/getToKnow/index.html
       https://phet.colorado.edu/en/simulations/number-play

(Richey et al., 2021). However, the role of "visual aids" for developing students' comprehension of place value remains questionable. The bundles of objects grouped by tens appear ready-made, and the operation of bundling is demonstrated and copied by junior "students," but the conceptual origin of positional counting remains hidden. It is thus a reasonable conclusion that children cannot simply "swallow" these "ready-made" concepts, which look efficient to adults; they need to reconstruct them on their own (Kamii & Joseph, 1988; Lai & Fung, 2018).

Sometimes the appeal to system counting is prompted by comparing it with well-known non-system measurements (time, weights, calendar, money), as they were established ages ago. Another feasible approach is to reconsider the basis of familiar numerals through other-base systems. An obvious way is to use other-base systems to support students' generalization of the place value principle, which has already been learned through decimal counting. Students are supposed to transfer the concept of place value to another-base system, either as an additional range of tasks for 5th graders (Gelfman & Kholodnaya, 2019; Gelfman et al., 1991; MacDonald, 1972; Vilenkin et al., 2023), or as an introduction to computer science and IT learning in high school. This approach to the development of place value comprehension is sometimes considered applicable not only for school students, but even for "grown-up" prospective teachers (Thanheiser & Melhuish, 2019).

An alternative method is to introduce other-base systems before examining the decimal system's structure. As examples of the developmental instruction curricula have shown, in primary school it is possible to pose the problem of invention of positional numeration through working with measuring tools of different sizes (Aleksandrova, 2009; Davydov et al., 1994; Zaharova & Feshenko, 1992). The students' task is to measure and build up magnitudes with a special set of measuring tools, which allows precise operations with large and small values at the same time. The ratio between "neighboring" measurements may either change, or be invariant. The latter serves to build up the multi-digit number in the system of counting with a corresponding base. This "twist" has already proved to be fruitful, and appropriate educational materials have been designed. Students in these classes mastered actions (measuring, comparison, simple calculations with carries, etc.) in different numeral systems and performed fluent transition to decimal counting as a particular case of positional notation.

This approach, from our point of view, is productive for analyzing the development of the multi-digit number concept; it allows students to perceive the evolution of methods of counting and to reconstruct the origin of the numeric systems. The construction of the multi-digit number for other-base systems may also provide the content for digital support of the initial steps in learning mathematics, as well as for the transition period between primary and secondary education.

Our general aim was to examine the content and means of actions substantially linked to the formation of the proper multi-digit number concept, which are to be scaffolded by the computer. We strove to set the problem of multi-digit number arrangement within a meaningful context, and to provide our educational design approach with computer support. The appeal to the structure of the multi-digit number, which reflects the way it was obtained, is assumed to be the actual means of solving various tasks in the corresponding domain — and thus, a sequence of evolving learning situations may be based on it.

According to Davydov (2008), the origin of a concept may be revealed through students' own actions within a learning task by immersing the students in a problem-solving context, where the multi-digit number has not been introduced ready-made, and the method for reaching the solution is not demonstrated by the teacher through simple visual aids. The choice and design of the context and the material to scaffold the students' own actions which can reveal the meaning of the number notation, are needed.

The main idea of an educational module using other-base counting for students familiar with decimal counting, is to provoke "active" reflection on the foundation for the numeral systems. The necessity to count and calculate in other-base systems sets up a contradiction between the "conceptual" way of solving problems and "natural" familiar decimal numeration, and maintains the relevance of orientation procedures. According to Galperin (1992; 2007, see translated Galperin's lectures in Engeness, 2021) and Talyzina (2018), the design of tasks which require overcoming salient features of the situation, is the indispensable condition for "conceptual" thinking development. Therefore, the priority task for an educational designer who follows the Activity research tradition, would be the construction of learning situations and the choice of relevant student actions for the corresponding concepts formation.

Thus, the goal of the current study was to develop and test a sample educational module, including the digital environment, aimed at students' acquisition of the place value concept in general, and at conscious operations with decimal numbers in particular.

## Methods

For the purposes of our study, we designed a computer-based educational module called "Interstellar wanderers." The model builds upon students' reflections on the basics and principles behind familiar decimal counting, which is provoked by the contradiction between calculations in other-base systems. The experimental teaching was conducted in four small groups (a total of 20 students, from 8 to 12 years old). The lessons (of 40-50 minutes) were held twice a week as an elective module (over 30 lessons for each group); thus, students' participation was voluntary. The digital support ran on the web within a standard browser and was developed using HTML/JavaScript. The materials were deployed on the web-based learning management system (https://counter.digitar.ru), which logs all the participant's actions.

For each lesson, students received a small homework assignment: several "practical" tasks, set within the same digital environment, which required them to move forward through "training flights," based on their progress along the outlined trajectory of the concept's development. The problem-solving could not be reduced to unconscious reproduction of the classwork tasks; the development of each solution demanded that they externalize the orientation procedures anew. These solutions, as well as the mistakes made, were then discussed in the class. Classroom observations, students' materials, tests, video-taped classroom discussions, and the logs of students' individual homework in the digital support software were used as data sources. The authors of the educational module observed the lessons (through videos, online, or in person) to ascertain that the students' activity was relevant to the intended one.

Students' promotion within the module was scaffolded by the digital environment with challenging tasks, educational texts, and the special externalized modeling space. The software thus supported the "executive" actions, and the "orientation" part was performed by the students in materialized form (Galperin, 2007; Engeness, 2021), which called for laying counting tokens on the table (an analogue of the real "counting table" was provided in the digital environment to support students' joint inquiry online).

The students were invited to join a team of rescuers, who are following the trail of cosmic pioneers who have gone missing for a long time. The "Flight log" (*Figure 1*) has been passed along to the traveling rescue team with some fragments missing (coincidentally in the most important places) and describes the difficulties which the pioneers faced as they tried to communicate with alien-run refuel stations through their common decimal numbers. It contains dialogue fragments and some photos taken by the characters, written notes, and some of the destinations the pioneers were headed to.
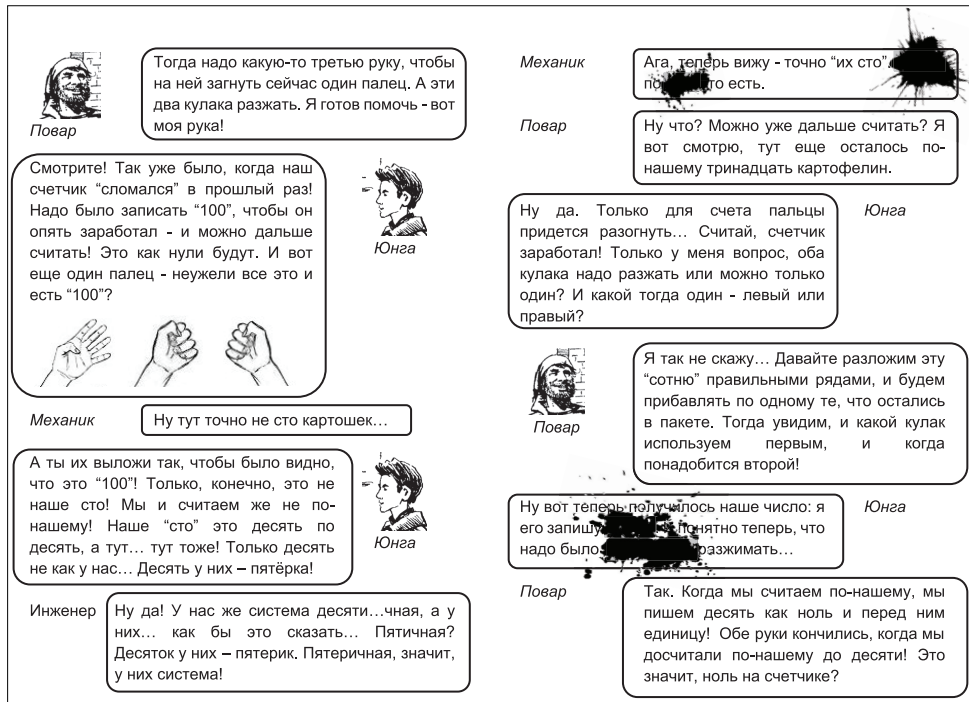


*Figure 1.* Students' textbook — the travelers' "Flight log" with ink stains

The computer simulation presents the sequence of "galaxies" which the pioneers have to travel through (the "Map" — see *Figure 2*) and the interface of the cabin screen with the slot for numbers, used to communicate with the refuel station in each "galaxy" on the way (the "Cabin view" — *Figure 3*). Students are to calculate the exact amounts of "cosmo-fuel" for different-base counting systems for each "cosmo-hop" which they make. If there is not enough, or too much fuel, the flight brings them nowhere — and they have to start anew.
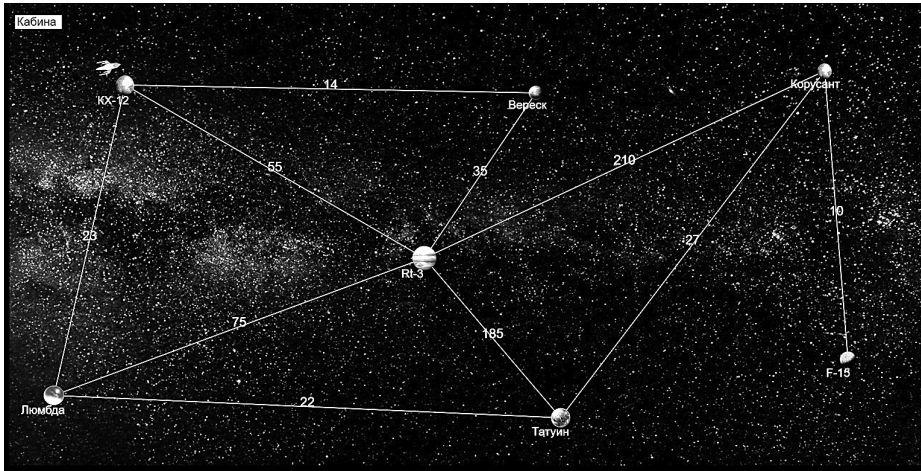
*Figure 2*. Map screen

*Note: the numbers on the map show the amount of fuel needed to travel from one destination to another (in Earth's decimal counting). The spaceship (left top corner) marks player's current position*
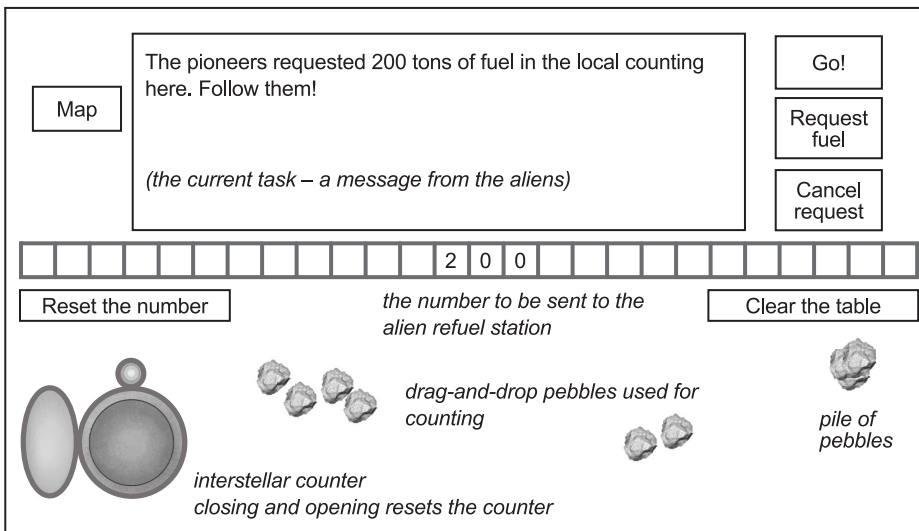


*Figure 3.* The Cabin view

*Note: the screen was replicated from the real screen view in order to translate all text boxes from Russian*

We outline the students' progress through the introductory "chapter" (the first of 12) of our educational module below:

The story starts as the pioneers request 23 tons of fuel at the cosmic refuel station for the destination they are heading to. However, the spaceship fails to reach that destination, and the pioneers find out that the aliens gave them only 11 tons of fuel. Did the aliens maliciously trick them? As the record of the dialogue between the characters in the flight journal shows, there was a "misunderstanding" due to aliens' "exact understanding" of our numeral notation according to their "local" way of counting.

"We count just normally, like everyone does," answers the alien when asked how they count. That is the key phrase, as it directs the pioneers, and hence the students who are "helping" them, toward analyzing the basis of their own counting system. Our experimental teaching showed that this phrase does not go unnoticed: students consider it a lie at first, as they obviously cannot get the needed amount of fuel with the number they dial. They will return to this phrase in the middle of the lesson, as they start to question what exactly there is in the aliens' way of counting that is similar to our own. At the end of the chapter there were always students who would exclaim: "The aliens were right!"

The difficulties of communication with the refuel station only set the problem and the meaningful context, but do not yet pose the learning task itself. The task appears as students have to overcome the discrepancy between the special counting procedure with the tokens in a materialized modeling space, and the "natural" decimal counting system which uses familiar numerical notations. This new additional modeling space emerges as the characters (the pioneers) notice the "interstellar counter" in the cabin; this object looks like an old clock to Earth dwellers (*Figure 3*). However, there are no hands, and the clock face lights up and makes a sound for each touch. The aliens say that this device is used to count "worldwide."

> Text fragment #1.
> Operator: The aliens say that it's the interstellar counter. Each click on its face means "one." They usually use some items for counting: they put one token and click once… Then the counter helps to write the number in the slots for the refuel station's terminal.
> Technician: We need to get twenty-three tons of fuel — what is there to count?
> Skipper: No, we should still use the counter. Oh, there are even some pebbles here! Perhaps, they were left for us so we could use them for counting. Let us take twenty-three stones and…
> Sea cadet: Well… We have done everything, as they said: put the stone — clicked the clock face, put the stone — clicked… But now it has ceased to count. The clock face glows and cannot be clicked again.
> Technician: Perhaps, it broke down? Ask the aliens!
> Operator: I showed them our counting table. They say that everything is okay: "It's 100, that you have collected. Now you have to write 100 in the slots of the terminal and then you can count further."
> Captain: Do as they say!
> Technician: We have written 100.
> Engineer: It's clear now! Of course, they gave us too little fuel. They already have 100, but we only have *** [stained with inks]. We were short for these many stones, I mean, tons of fuel: ***.

In the fragment above, the key plot element is set: counting "by the clock" cannot be continued after a certain amount, which is "100 in the local system." It is here that counting is connected to the process of obtaining one "hundred." Students have to perform counting just the way the characters (rescuers) did. Then they will know that the clock "broke" after sixteen counts, which means that "sixteen" in our decimal system is marked as "100" in the local counting system. Although the characters try

to persuade the students to do the counting themselves (see the skipper's and captain's replies in fragment 1), our teaching experiments show that students at first do not follow the characters' advice, but rather try to find ready "answers" in the text. They are obviously not ready for the type of digital support which demands actually operating the objects on the screen according to the text description of characters' actions, which have no direct link with familiar "math activities."

Even after repeating the first part of the operations needed ("put the pebble — click the clock — put the pebble — click the clock" and so on until the clock "broke"), they could find the 16 pebbles, but could not connect "our" sixteen and the alien "100." They could grasp this connection only as they put 100 in the terminal slots (as the text tells them to) — and the "counter" stopped glowing and could be "clicked" again.

How should we count if we are to reach "100" on "our" sixteenth count? The aliens state that they count "like we do." Students thus have to coordinate "our" common way of counting towards 100 with the given amount (16), which has to be re-counted to get alien's "100." It is here that reflection on the foundation of familiar counting becomes urgent: the "conceptual" content of place value in positional decimal counting is usually disguised with the "natural" appearance of decimal numeration, which has "10" after "9," as there is no special "tenth" symbol. For other-base systems (less than decimal) we can easily suggest symbols for their "tens," but for some reason they have to write "10" instead of 4 (in base-4), or instead of 7 (base-7 counting). In this respect our own decimal system thus seems the only "true" one, and others are regarded as weird derivatives.

"Disassembling" the new "hundred" to appropriate "tens" is introduced as the special action which will allow students to overcome their "obsessive" decimal counting attempts to calculate the needed fuel. This procedure will further be used for operating in the local numeral system, maintaining the consistency of counting, which is first revealed in the "hundreds" digit. Hence, the next step in the narrative is to "break" the 16 pebbles which comprised the aliens' "hundred," into bundles of "tens." Various options, like 6 and 10, or 2 piles of 8, or 8 pairs, are rejected by the characters…

> Text fragment #2.
> Skipper: It is not evident here. You were collecting tokens — how did you say — ten times ten… we should try the same here.
> Sea cadet: We don't have enough pebbles for that! Even two times ten cannot be made with sixteen…
> Skipper: They can. They also make "ten times ten," so should we… But we have to reach their "100" sooner, than our "100."
> Sea cadet: Then the piles have to be smaller. Oh, I see… "this amount" by "the same amount"! As many piles as the number of pebbles in the pile. I gather now, how they count…
> Technician: The aliens were right; they indeed count as we do. But their "ten" is not the same as our ten, it is *** in our words.

The students are left with 16 counting pebbles and the "stained" spot here. The essential words "this amount by the same amount" and "ten times ten" are in no way

a direct instruction or a ready-made answer. The guidelines for students' action — which would look like "arrange the 16 pebbles so that "ten times ten" makes 100" — are yet to be retrieved from these key words, which typically were ignored by all our participants at first. Therefore, the students test the idea of "system counting" in general, according to its orientational function. It is remarkable that the students were not able to solve this task (which perhaps looks simple for adults) until they took the counting material in their own hands (either actually or virtually) and started to put them in the piles. Students then had to tell each other and themselves "ten," as they laid down four pebbles, and they were to repeat it up to "ten times ten" and lay down four piles of four pebbles each.

Thus, here the orientation procedure is externalized as "piling up" the counting material. Students will appeal to this means during initial steps through the "Flight log" and the "training flights:" it will help them mediate their counting by the names and symbols used to operate multi-digit numbers. For example, the students will later on solve the arithmetic equations with "stained" numbers in other-base systems (*Figure 4*), which will demand the comprehension of the digit structure, and the appeal to different counting materials will serve as means for modeling (instead of ready-made illustrations of actions' results typical of primary textbooks).
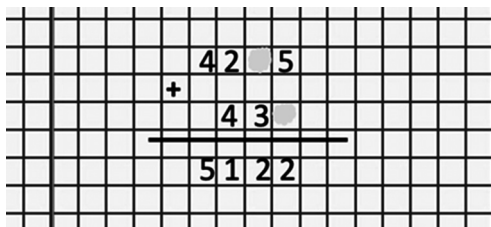


*Figure 4.* The scrap of paper with some missing numbers

## Results

The built-in assessment of the reasonableness of students' solutions was the analysis of students' performance in the "training flights." The logs of each students' homework could be considered by the teachers and researchers, both qualitatively and quantitatively. In-depth analysis of the mistakes students made allowed us to distinguish between their attempts to apply the concept-mediated procedures learned in the class and random "guessing" strategies. The example of the latter is presented below (*Table 1*).

Task example 1 (the introductory chapter): "The aliens on the Tatuin say that the pioneers requested 200 tons of fuel in the local counting system and flew away. Where did they go?"

The students are supposed to open the "interstellar counter," prepare the pebbles and count up till the counter stops to show local "100," which will be our 9.

The map suggests several routes (in decimal counting): to Korusant (81), to Ymba (18), to Lumbda (109) and to Argo (200).

**Table 1**

*Logs' fragment: a student is conducting a training flight*

| Time | Action | Our comment |
|---|---|---|
| 11:29:20 | fly .. Oiro -> Tatuin .. success | *the previous successful flight* |
| 11:31:28 | fill up .. 18 .. fail | *fuel fillup failed, as there is no "8" in local base-3 system* |
| 11:32:22 | fill up .. 200 .. success | *"200" fuel in local counting was successfully obtained…* |
| 11:32:23 | fly .. Tatuin -> Argo .. fail | *… but the flight to Argo failed (it requires "200" in decimal counting)* |
| … | … | *12 more random attempts (failed)* |
| 11:39:37 | fill up .. 21 .. success | |
| 11:39:43 | fly .. Татуин -> Арго .. fail | *student stops trying* |

According to this part of log, we may assume that the student at first counted with the counter one "hundred" (nine pebbles) and then added one more "hundred" to get "200" (which is 18), but after that he tried to send the number "18" to the aliens, which they obviously could not accept. The student, perhaps, spent 1 minute reading the task again and then dialed "200" in the slots (which was indeed the alien number, which the pioneers also used). But as the student looked at the map, he was distracted by the Argo destination, which had "200" in decimal counting (a "pitfall" placed on purpose), chose it as the destination and failed. After that followed 13 random trials, but the task remained unsolved.

In this small fragment the student falls into the trap of "visuality" two times: first, he uses our "18" for the aliens, and then he searches for the alien "200" between decimal numbers on the map. Through the logs analysis, we can observe the progress of students who adopt the orientation procedure as their own means of acting within the digital simulation. Indeed, the log of this student on another day shows that he did this and other tasks in the series without false trials, and each problem took about 2 or 3 minutes for him to solve (to read and to perform the correct procedures).

**Table 2**

*The comparison of students' "strategies"*

| Students | task #1 | | task #2 | | task #3 | | task #4 | |
|---|---|---|---|---|---|---|---|---|
| | Time spent | Failed trials | Time spent | Failed trials | Time spent | Failed trials | Time spent | Failed trials |
| student F | 0:57 | 0 | 9:31 | 1 | 4:47 | 0 | 3:29 | 0 |
| student G | 2:47 | 0 | 4:10 | 0 | 7:55 | 0 | 3:24 | 0 |
| student H | 2:14 | 1 | 6:38 | 1 | 6:04 | 1 | 1:33 | 1 |
| student I | 0:55 | 2 | 2:51 | 4 | 1:39 | 2 | 0:32 | 0 |
| student J | 1:43 | 0 | 0:36 | 0 | 1:55 | 4 | 1:41 | 1 |

*Note: "0" failed trials mean the destination was reached successfully on the first attempt.*

The quantitative analysis to describe the progress of each student may use information about the time spent on the task, and the number of trials (successful and failed), which can be retrieved from the logs of students who successfully completed the tasks from the training flight with one or more attempts each.

The example also concerns tasks which demand choosing the destination which fits with the local number of cosmo-tons given. We can see from the log (see *Table 2*) that sorting through all variants may lead to success here. Yet, some students did not follow this path.

> Task example 2: "The pioneers filled up 1000 tons of fuel in local counting here for their next cosmo-hop. Determine their destination and follow them!"
> The "counter" stops on the 36th "click," showing that the local "100" is the same as "our" 36. Thus, it is a base-6 system, and students have to take "ten" times "hundred" to get a "thousand", which means 6 times 36 in our count.
> Possible destinations: Luc (64), Marlo (1296), Tabu (216), Kani (360), and Rubicon (81).

As we see from the table, students I and J are spending very little time on each task and are doing a number of trials, which means that most likely they were guessing the answer, trying one destination after another. Sometimes they were lucky and succeeded with the first trial, and sometimes not. The other two students, F and G, apparently were those who performed the orientation procedures (arranging the pebbles to make "ten times ten," recounting the necessary amount of fuel, etc.); they spent more time on each problem, but they made almost no failed trials. Student H was perhaps trying to solve the problem as required, but each time made some mistakes, which could be discussed and resolved during the next lesson.

An important indicator of the students' progress throughout the module for educational designers and for the teachers was the decrease in the number of failed trials, especially the disappearance of "random guesses" (several failed trials performed within a small period of time). In our experimental teaching the number of "random" trials came down to an insignificant minimum. It is worth mentioning that the number of failed trials also decreased when the students were performing their tasks in groups rather than individually, and held a discussion (the teacher did not take part).

The tasks were specially modified throughout the development of the problem situation to keep the tension, in line with Galperin's principles of active orientation scaffolding against stereotypical reactions and resorting to irrelevant "round-about" methods (Galperin, 1992, 2007; Engeness, 2021). Thus, the attempts sometimes failed due to the increasing difficulty of the tasks, and the time spent on each task could grow accordingly (student J, *Table 3*).

> Task example 3 (the last chapter). For the next cosmo-hop the pioneers tried to guess the local system and wrote down the number of cosmo-tons in the base-2 numeration: "111001". However, the aliens from the current refuel station said: "Are you sure? It is enormously far from here. Bear in mind that your "five" fingers, as you call them, is "12" fingers in our counting. Request the appropriate amount of fuel and proceed further."
> Possible destinations: Crocus (11), Jot (111), Het (5), Zews (57), Dub (49).

**Table 3**

*Systemized logs' information: solving a series of tasks of increased difficulty level*

|  | task #1 | | task #2 | | task #3 | | task #4 | |
|---|---|---|---|---|---|---|---|---|
| **Students** | **Time spent** | **Failed trials** | **Time spent** | **Failed trials** | **Time spent** | **Failed trials** | **Time spent** | **Failed trials** |
| student L | 1:20 | 0 | 4:20 | 0 | 1:53 | 1 | 2:37 | 1 |
| student M | 1:21 | 0 | 9:08 | 0 | 0:53 | 0 | 3:22 | 1 |
| student N | 1:34 | 0 | 16:34 | 5 | 2:32 | 0 | 18:40 | 6 |

*Note: "0" failed trials means the destination was reached successfully on the first attempt.*

The results of the teaching series proved the potential of the content and the computer support which we have developed. The educational module scaffolded students' progress in a way which made it possible to proceed with each following lesson, as an extension of the previous one. Moreover, the students themselves could set the new task, as they were immersed in the content and could see the further development and consequences of their current problem. The story of the cosmic pioneers gradually faded into the background and the students got more involved in the objective relations within the numeral systems. Since the contradictions between "how it seems" and "how it should be done according to the concept" were themselves maintaining the tension, the characters' statements were only making these contradictions more vivid. There was no need for "extra external motivation" to keep students busy with problem-solving. The substantial progress of our students within the regular mathematics curriculum was confirmed by an expert assessment and their performance on common written math tests on corresponding topics.

## Discussion

The digital environment which we have designed for the "Interstellar wanderers" module, provided essential support for setting up students' substantial reflection on the structure and functionality of positional counting as what Davydov called the specific learning task (Davydov, 2008). The appeal to orientation procedures within a special modelling space (the counting of tokens, which problematized the use of current digits' measures) was supported constantly through the educational text. The narration of the "Flight log" provided hints and clues on the required orientation procedures according to their fundamental functions, and set them as the means of communication between the characters about the problems which arose along the way. Trivial but false ideas were uttered by the "crew members" to prompt the students: they represented the tempting "roundabout" easy ways of handling the matter, which are to be rejected on the basis of "concept-mediated" actions. Each cosmo-hop not only served to check the answer, but allowed further development of the learning situation.

Control over the correctness of the answer was moved to the special modelling space: there students checked the reasonableness of the way they presented this or

that number in decimal or other-base counting. Thus, students refused to check some answers unless there was substantial modelling behind them. It was the method of modelling, not the answer itself, which had to be verified. The "abrupt" introduction of an alien "hundred" as the digit which concealed and at the same time allowed the general structure of the multi-digit notation to unfold, showed vast potential to immerse students into the contradictions between the "conceptual" and "familiar" within the positional counting. Students thus learned to evade popular mistakes in everyday common calculations in the decimal system.

The simulation of the "intergalactic" flights as presented, created a special environment wherein the students were comparatively free in their actions, had clear goals, and were confronted by real challenges which did not depend on the teacher's will. The teacher was not there to judge the correctness of the students' answers; on the contrary, when the students asked for the teacher's comment and opinion ("Am I doing it right?"), he had them return to the content of the situation instead: "Look, you haven't reached this galaxy." He might even prompt wrong decisions and confuse the students, so that after their joint failure, they would have to teach the teacher the conceptual way to handle the matter. The productiveness of the students' discussions and their progress, which happened as it was intended to, indicate the relevance of the designed content for supporting the students' model actions, and justifies the chosen approach to the digitalization of school lessons.

## Conclusion

The prospects of providing common educational content by digital means seem doubtful; making traditional visual aids more and more vivid and eye-catching has not yet brought any "breakthrough" in students' comprehension of place value in particular. On the contrary, the approach to computer support design based on the general principles of Activity Theory in education has once again proved to be feasible and productive, although it does not produce the same abundance of software samples.

The basic principles of digital environment design, which have already been tested in our previous studies (Rubtsov, & Ulanovskaya, 2021; Vysotskaya et al., 2017; Vysotskaya, Lobanova, & Yanishevskaya, 2022), are: support for students' purposeful transformations performed with objects, and the organization of special additional modelling space on the screen. However, these principles can be applied only after the concept's origin has been reconstructed, and a feasible hypothesis on the content of students' appropriate orientation procedures has been formulated. The digitalization provides new opportunities for conducting a lesson, but bears the substantial risk of strengthening students' mindless attempts to knock the answer readymade from the computer, without delving deep into the matter ("gaming the system," according to Richey et al., 2021). In this regard, the analysis of the concepts' content and origin is even more urgent for the design of educational modules with computer support.

Students' engagement in the content of the school disciplines itself through specially designed digital environments remains an urgent issue (Belolutskaya, Vachkova, & Patarakin, 2023). We assume that our approach may extend teachers' opportunities for using digital environments ("gaming," in particular) for educational

purposes (Lampropoulos, 2023; Papadakis, Zourmpakis, & Kalogiannakis, 2023; Ruthven, Hennessy, & Brindley, 2004; Zourmpakis, Papadakis, & Kalogiannakis, 2022). Therefore, further investigation should describe in detail how this approach promotes students' progress in conceptual reasoning.

## Limitations

In the pilot project, we focused most on the correction of learning materials and update of the software's functionality. Thus, serious testing of the learning module on a bigger sample, and its refinement for use by a regular teacher is the goal of our future research.

## Ethics Statement

The study followed the ethical guidelines of the Institutional Ethics Review Board (ethical approval #3 issued on April 25, 2022).

## Informed Consent from the Participants' Legal Guardians

Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## Conflict of Interest

The authors declare no conflict of interest.

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# Ground Rules for Preschooler Exposure
# to the Digital Environment: A Review of Studies

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**Background**. The range of digital technologies that children use from an early age has expanded significantly. Most studies demonstrate that preschoolers now spend substantially longer on digital devices and start using them at a younger age. Finding a solution for this challenge has research merits and relevance, as the data on benefits and harm of early preschoolers' exposure to digital devices is contradictory. This poses a need to determine theoretically sound and practically validated criteria that could guide the duration and quality of children's exposure to the digital environment.

**Objective**. To review studies that contain recommendations on preschoolers' exposure to the digital environment, namely, exposure limits and evidence to justify the limitation of preschoolers' time on digital media.

**Design**. The analysis starts by identifying theoretical foundations that researchers use in their studies of children's behavior in the digital environment. This is followed by an overview of 40 studies that include research papers, official reports, and methodological recommendations made by healthcare and governmental organizations.

**Results**. The review identified the following ground rules for children's exposure to the digital environment: to provide for child's interaction with a digital device, to use educational applications that will develop skills appropriate to the child's age, to ensure mandatory supervision of children's engagement by an adult who limits the exposure according to child's age-related capabilities and creates conditions for active exploration of the real rather than a virtual world. Children's cognitive development suffers the most from passive intake of digital content.

**Conclusion**. The data herein can help to develop strategies to promote healthy and educational engagement of children with digital devices and media; however, the review highlights the insufficiency of psychophysiological research that would make it possible to practically validate the recommendations on the duration of preschoolers' exposure to the digital environment.

*Keywords*:
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## Introduction

Today's preschoolers are the first generation to grow and develop fully in the new digital environment and even to be known as digital natives (Sharkins, 2016). Whereas pre-pandemic, it was thought that even primary school children should not be exposed to the digital environment for longer than 20 minutes a day, during the pandemic the duration of digital technology use by children increased significantly (Limone & Toto, 2021; Nikolaeva et al., 2021; Uğraş et al., 2023; Zhang et al., 2022). Today's children are often introduced to an information-dense digital environment before they turn one year old. They have daily access to new opportunities that are not available in the real world around them (Elias & Sulkin, 2017; Ewin et al., 2021; Griffith et al., 2020). Children in Russia were found to receive a personal digital device (smartphone, tablet, smart watch, etc.) when they are 3 to 6 years old (the data range is 42% to 68%) (Kalabina & Progackaya, 2021; Korotkova et al., 2018).

According to parents in Russia surveyed by Nikolaeva and Isachenkova (2022), 10.2% of children under the age of four have their own digital device ("gadget"). In this group, 1% of the children were still under the age of two. Other research shows that preschoolers have good technical skills to confidently use digital devices, especially through touchscreens (Chaudron et al., 2018; Kalabina & Progackaya, 2021; Papadakis et al., 2021; Veraksa et al., 2020). From an early age, children are surrounded by various electronic devices and mobile information tools. Their impact on children's physical, mental, and socio-emotional development is poorly understood (Blackwell et al., 2014; Kılıçer & Çoklar, 2015; Plowman et al., 2010). There are even fewer studies of very young children (Elias & Sulkin, 2017; Twenge, 2019).

### *Theoretical Basis for Assessing Time Limits on Preschoolers' Exposure to Digital Media*

Prior to assessing the scientific foundation, we would like to emphasize that our definition of "screen time" covers the time children spend on a particular gadget or at the computer plus the time children stay around a working TV. This enhanced definition reduces the novelty of the problem, yet makes it all the more relevant, since some parents leave their children next to a working TV all day long to keep them away from gadgets (Kirkorian et al., 2016, 2018).

### *Screen Time and Television*

Electromagnetic waves emitted by TVs, together with the sense of security children feel being around adults, are known to produce a reflex, such that a television relieves anxiety and calms children down. This contributes to a lifelong dependence on keeping the television on (Kubey & Csikszentmihalyi, 1990).

Television has been present in children's lives for quite some time, and there have been longitudinal studies of screen time. Some studies showed that when a child under one year of age watched adult TV programs, the quality of this child's executive functions at age 4 was impaired and his/her linguistic abilities in elementary school suffered (Barr, 2019; Scarf & Hinten, 2018). Moreover, every extra hour of TV screen time before one year of age was shown to weaken the child's attention by 28% at age 7 (Christakis, 2004). And if the TV is on while the child and an adult are playing, the

adult is less cognizant of the child's needs and does not speak to the child or respond to his/her questions quite as often. This generally degrades the quality of their communication (Hanson et al., 2021).

### Critical Periods of Early Ontogenesis

One of the most important scientific concepts providing the foundation for an overwhelming number of researchers is the theory of critical periods of early ontogenesis. The theory describes special periods of brain structure plasticity at certain stages in child development (Carson et al., 2015).

Imprinting is one of the first postnatal periods. At this time children capture their parent's image as an ideal benchmark. That explains why researchers are concerned about parental behavior and their screen time, since children have been found to copy them once they become adults (Corkin, 2021). The other most important critical period is that of speech development, which terminates by the end of the preschool age. It has been repeatedly shown that normative speech development begins with the use of personal speech that accompanies a child's independent play. In one study, five-year-old children were first asked to build a tower with physical blocks, and then to do the same using a tablet. The study registered a significant reduction in speech activity when the task was performed on the gadget (Bochicchio et al., 2022).

### J. Piaget's Theory of Children's Cognitive Development

The concept of critical periods to a great extent ties in with the theory of J. Piaget (Piaget, 1965), which describes preschoolers' intelligence development. The main theoretical construct is that sensorimotor coupling acts as an equivalent of notions used by adults. The coupling is achieved when the child explores real world objects and engages with them. According to Piaget, prior to facing a symbolic representation of an object in a picture or in a verbal description, the child must get acquainted with it in the real world, feel it, lick it, and otherwise try to interact with it. Only this sequence will shape object's mental schema in the child's mind and enable him or her to cognize the object's symbolic form. Figuratively speaking, the child must first see a chicken, and then listen to "The Speckled Chicken" fairy tale. Disregarding this process was found to impair the formation of cognitive functions and to result in an inability to discriminate the trustworthiness of sources (Richert et al., 2010).

Piaget's proposition initiated a great number of works confirming its relevance to the use of gadgets with content inappropriate to a child's age. We have already mentioned that watching adult programs on TV by children under 2 years reduces their cognitive abilities later on. First of all, a child under 2 years of age has a limited understanding of the content on 2D screens (Radesky et al., 2016). The transition to 3D contexts develops slowly during early childhood. Consequently, children of this age cannot relate a complex video image — including complex speech expressions, often unknown to the child — to reality (Ziemer & Snyder, 2016).

One part of Piaget's theory has a direct match with all the provisions of child learning and cognitive development theories (Liberman,2021). It states that appropriation of information requires the learner to stay active. It also warns about negative

consequences that passive information acquisition will have primarily on cognitive control, which is the most important parameter responsible for a child's behavioral changes and metacognitive functions (Marulis & Nelson, 2021).

### *The Role of Motor Activity in Learning*

Motor activity is an essential component of child development and learning. The validity of a baby's picture of the real world is determined by the development of his or her vestibular system (Kim, Avraham, & Ivry, 2021). The accuracy of the picture that the brain creates by analyzing information from receptors is achieved via image corrections based on the head-to-body position. To give three-dimensionality to a flat picture of the surrounding environment presented on the retina as the brain processes information, children must crawl, run or walk to the object many times from different angles, holding their heads in different positions. For that reason unlike all other sensory systems, the vestibular system does not have a simple analyzer in the brain, but rather embraces all brain structures like an octopus. That makes it possible to ensure sensorimotor integration. The less children move, the less accurate is their picture of the outside world (Noel & Angelaki, 2022), the poorer are their metacognitive abilities — that is, the ability to monitor their own cognition (Alvarez-Bueno et al., 2017; Baliram & Ellis, 2019; Escolano-Perez, Herrero-Nivela & Anguera, 2019; Chen & McDunn, 2022).

When preschoolers are given a gadget — instead of less colorful (or sometimes just black and white) book images, where they are required to make an effort to either recognize numbers or letters or even to read — they have sensory experiences which may eventually substitute for other forms and ways of obtaining sensory information. This potentially poses a risk to the child's normal psychophysical development (Tsai et al., 2017; Woodward, et al., 2016). The most alarming evidence is that vivid images produced by gadgets and viewed by the child before he or she actively engages with the real world (i.e., before the age of one year) make the child feel "bored" in non-virtual reality, as its stimulation is less intensive. Later this was found to predetermine the vector of the child's cognitive development to a significant degree (Wolf, 2021). The intensive and uncontrolled use of digital technologies at an early age detaches children from true sources of development and poses a serious risk (Smirnova et al., 2018).

Encountering an image on television for the first time may positively affect some cognitive processes and accelerate their progress (Scarf & Hinten, 2018). However, it was found to have a negative effect later on, as children preferred passive actions with gadgets to active learning that would require resolving complex cognitive tasks (Madigan et al., 2020). The earlier a child encounters this attractive tool, the more likely he or she was found to choose passive perception over active learning (Kerai et al., 2022).

For that matter, learning applications developed for touchscreen devices promote children's active cognition and, as a consequence, improve their working memory, if compared to passively watched TV (Kirkorian et al., 2016; Papadakis, 2023; Papadakis et al., 2021; Vaiopoulou et al., 2022). These applications are developed on the same theory discussed above and factor in the specifics of sensorimotor integration when children perceive information.

### Sensorimotor Integration

The concept of sensorimotor integration requires that children under 4 years of age be presented with information on television at a slow pace and that images be maximally realistic and recognizable (Lillard, et al. 2015). But this does not engage the child's taste, vestibular, and olfactory sensations. Therefore, screen time should be limited to ensure that the child's real world activities are not hindered (Suggate & Martzog, 2020). In this regard, some authors emphasize that parents have time limits for interaction with the child, and therefore the more screen time children have, the less active they are in the real world (Scarf & Hinten, 2018).

### Epigenetic Influences

One more aspect is related to the epigenetic impact the early life environment has on the child's subsequent development. It has been demonstrated that certain upbringing conditions will contribute to changes in gene activity that in turn change the way human body functions (McLaughlin, Weissman, & Bitrán, 2019). One of the most important influences is attributed to stresses experienced in childhood. Stresses suppress genes that regulate responses to stress (Meaney & Szyf, 2005). Quite often parents give gadgets to their children to calm them down in tense situations, in which the parents are afraid of a public failure to pacify them by other means (Shin, 2021). This problematic solution starts a vicious cycle, allowing the children to use outside observers as leverage and to force their parents to give them the gadget by throwing a tantrum. Instead of resolving the conflict, this causes regular stress for both parents and children. Stress-released cortisol can be removed from the bloodstream only through motor activity (Kim, Avraham, & Ivry, 2021), which in this case is substituted by a gadget.

### Socioemotional Development

Finally, children's socioemotional development is the most important theoretical aspect addressed in many works. Preschool age is a critical period for socioemotional development (Desmarais et al., 2021; Wan, 2021). Many Russian parents show their preschoolers cartoons that were made for children in the USSR. These TV cartoons often have a very strong moral aspect. Parents tend to think this will contribute to the development of child's moral standards. A study by Mares et al (2018) in the United States examined the prosocial behavior of children who were 3 to 5 years old. In the research, 107 children watched cartoons that presented moral behaviors. It turned out that the preschoolers did not understand the content well enough and in the subsequent behavioral tests they did not demonstrate the behaviors promoted in the cartoons.

Many studies are contradictory (Cajochen et al., 2011; Clowes, 2018; Coiro, 2020), which highlights the need to develop evidence-based recommendations that would provide ground rules for preschoolers' exposure to the digital environment. These recommendations should correspond not only to researchers' theoretical assumptions, but also to the realistic capacity of families with children. All of the above has determined the purpose of this article: to review papers that — at varying depth — provide evidence for ground rules for preschoolers' exposure to the digital world.

**Methods**

Given the conflicting evidence on the benefits and harm of preschoolers' experiences with digital devices and media, this article analyzes research, official reports, and methodological recommendations made by healthcare and governmental organizations that contain data and guidelines on preschool children's exposure to digital media. The literature search for this review was done via Google Scholar, PubMed, Research Gate, and Web of Science. Search keywords: digital environment; digital devices; digital media; early childhood smart devices; impacts of screen time; screen exposure; screen time; parental mediation; preschool children; preschooler cognitive development; preschooler socioemotional development. The review includes studies that: 1) contained proposals or requirements that could form a regulatory framework, describing the rules of digital exposure for children aged 4–7 years; 2) contain justifications for limiting the time preschoolers spend on digital media. A total of 40 publications were reviewed: 11 publications referred to preschoolers' time in the digital environment and 29 publications had research data on how the digital environment impacts preschoolers. These studies in varying degrees justify recommendations and restrictions on preschoolers' time in the digital environment. Publications that only cited limits on preschoolers' exposure to the digital environment and findings of earlier studies were not included in our review.

**Results**

***Guidelines for How Long Preschoolers May Spend on Digital Devices***

Although digital technologies are increasingly important in our lives, some researchers claim that they harm children's health (Anderson & Rainie, 2018). Perhaps most telling was a cognitive ability study of video gamers who began gaming as children in the 1980s and continue to play the games as adults. Excessive gaming time definitely resulted in attention deficit, social communication difficulties, and a higher risk of obesity. But some gamers were found to have cognitive advantages compared to an average subject who does not play computer games. The gamers were highly adapted to processing various types of visual information, had better spatial visualization and shorter response time to external stimulus, and were able to rotate objects in their heads. It was demonstrated that video games limited to 1 hour per day for approximately 4 days a week in 6 months improved the subjects' visual vigilance (the ability to discern and process visual information), spatial attention, and multitasking (Green & Bavelier, 2003).

In response to this challenge, a number of organizations and researchers have developed specific recommendations on the duration of and conditions for children's use of digital devices. Of the publications we analyzed, 12 provide direct recommendations about how long children may use digital devices and/or screen time. These recommendations are not quotes from other sources. Table 1 presents the data in the publications' chronological order.

These guidelines make a significant contribution to shaping the environment that will promote preschooler development, especially with regard to digital exposure. However, the evidence for the guidelines is not always clear. More evidence is needed

**Table 1**

*Guidelines on how long preschoolers may spend on digital devices*

| Source | Requirements of digital exposure for children | Type of publication |
|---|---|---|
| Australian Department of Health, 2012 | Children under the age of 2 should not watch television or use any digital devices. | Report |
| National Association for the Education of Young Children & Fred Rogers Center for Early Learning Children's Media at Saint Vincent College, USA, 2012 | Limit any use of technology and interactive media in programs for children younger than 2 years. Prohibit the passive use of TV, videos, DVDs, and other non-interactive technologies and media in early childhood programs for children younger than 2 years, and discourage passive and non-interactive uses with children ages 2 through 5. | Position statement |
| Hill et al., 2016 | Avoid introducing children younger than 18–24 months to digital media (except for video chats). For children aged 2–5 years, screen time should be limited to 1 hour per day. The guidelines recommend ensuring high quality content and parent–child media sharing. | Policy statement |
| Canadian Paediatric Society Digital Health Task Force on Okanagan, 2017 | Screen time for children under 2 years of age is not recommended, whereas for children aged 2 to 5 years the limit is 1 hour per day and no screen time 1 hour before bedtime. | Position statement |
| Early Childhood Australia, 2018 | Screens should be used for short time periods with regular breaks; screen time should not be a substitute for physical activity and digital devices and screens should not be used before bedtime. | Report |
| World Health Organization, 2019 | For children under 1 year of age, digital media and TV viewing are not recommended. For children aged 2 to 4 years, sedentary screen time should not exceed 1 hour. | Report |
| Soldatova & Vishneva, 2019 | Preschoolers aged 5–6 years ideally shall not use the Internet and digital devices for longer than 1 hour per day. | Research paper |
| Royal College of Paediatrics and Child Health, United Kingdom, 2019 | Families should negotiate screen time limits with their children based upon the needs of an individual child, the ways in which screens are used, and the degree to which use of screens appears to displace (or not) physical and social activities and sleep. | Guide |
| Sanitary Regulations and Norms, Russian Federation, SanPiN 2.4.3648-20, 2020 | Continuous screen use should not exceed 5 to 7 minutes for children aged 5–7 years and 10 minutes for students in grades 1 through 4 and shall alternate with mandatory eye exercises and physical education breaks. Mobile digital devices are not used for educational purposes. Electronic educational devices are not used for children under 5 years of age. | Decree |

| | | |
|---|---|---|
| Hygienic norms and special requirements for the device, content and modes of work in the conditions of digital educational environment in the field of general education. Guidelines, Ministry of Health of the Russian Federation, 2020 | The total recommended daily time spent on digital devices and e-learning tools for children aged 6–7 years is 80 minutes. It increases to 90 minutes in grade 3 (starting 9 years of age). | Guide |
| Pivovarova et al., 2021 | No use of tablets or mobile phones by children under 2 years; screen time for children aged 2 to 5 years should not exceed 1 hour per day; avoid using gadgets 1 hour before bedtime; no background TV. | Research paper |

to separate the impact of screen time from other factors influencing children's health (Ashton & Beattie, 2019).

### *Justification for Limiting Preschooler Exposure to the Digital Environment*

Some publications contain data on how various aspects of children's physical health and development are impacted by excessive exposure to a digital environment. Reduced motor activity of children nowadays, as it is replaced by digital device engagement, has been found to result in degradation of children's physical aptitude, poor development of fine motor skills (Binnur 2015), overweight and poor health (Anderson, 2008; Marsh et al., 2013; McVeigh et al., 2016).

Children were found to be less exposed to sunshine because they spend more time on digital devices and stay indoors (Dresp-Langley, 2020). Continuous screen watching at a close range has been associated with vision problems in adolescents (Kim et al., 2016). The bright light from digital screens and digital content was found to excite the child and impact the falling asleep stage and sleep quality (Carter et al., 2016; Cheung et al., 2017; Lin et al., 2021). Though some studies found no correlation between sleep quality and a child's tablet or mobile phone use, they identified a risk of sleep disorders as TV viewing time increases (Zhu et al., 2020).

Anxiety and depression triggered by excessive use of digital devices has been shown in studies of adolescents and is primarily associated with social media use. On the other hand, social media can be a good tool for children to develop social connections, especially for children with disabilities (Perezhogin, 2022). There were no studies of depression in preschoolers caused by digital device use. Moreover, many preschoolers associate the use of digital devices with positive experiences (Kalabina & Progackaya, 2021). Children feel joy when they succeed in digital games and applications (Warburton & Highfield, 2017).

The negative impact of digital devices has also been linked to behavioral problems in children. Lin and colleagues (2020) demonstrated that children aged 18 months to 3 years who use touchscreens experienced emotional and behavioral problems. A four-year longitudinal study tested the hypothesis that use of digital devices such as smartphones and tablets by 4-year-olds is associated with dysregulation symptoms

and lower academic achievement at the age of 6–8. Another study found that a child's screen time at age 4 is directly, positively, and significantly associated with dysregulation and negatively associated with math and literacy scores at age 8 (Cerniglia et al., 2020).

Positive outcomes were found by some researchers who demonstrated that early digital experiences of young children are beneficial for their cognitive development. However, these experiences may potentially negatively affect social and emotional development caused by a delayed development of age-appropriate social interaction skills (Cabré-Riera et al., 2019; Pecherskaya et al., 2013). Developing ways in which large screens in kindergartens are shared to create a single product can promote children's critical thinking and prosocial behavior (Sundararajan, Adesope, & Cavagnetto, 2018).

Positive effects of digital device use on regulatory functions, auditory working memory, cognitive flexibility, and inhibitory control have been confirmed in preschoolers who use digital devices once a week, compared to children who use them 3–4 times a week (Veraksa et al., 2022). Also, the appropriate use of digital technology can stimulate creative activities and promote creative abilities in young children (Fielding & Murcia, 2022).

Authors disagree on the effects of video games on cognitive abilities. The impact depends on gaming intensity and type as well as on the gamer's personal characteristics (Vedechkina & Borgonovi, 2021; Walsh et al., 2020).

A study that explored the association between the age when children start using gadgets and the cumulative effects of digital exposure through the initial 2 years of life on the one hand, and cognitive development at age 4 on the other, found that cognitive development at age 2 positively correlated with a later age of digital device use and with a shorter intense exposure to screen media (Supanitayanon et al., 2020).

It is important to distinguish between active and passive screen time. Passive screen time of 5-year-olds was found to correlate negatively with their math and science achievements, executive function, and social skills. In a study of Chinese children, active time in front of a screen correlated positively with the children's language skills and knowledge of science (Hu et al., 2020).

A longitudinal study that identified how passive viewing and active use of digital resources correlate with preschoolers' executive function and psychosocial development concluded that limiting the use of electronic applications to 30 minutes or less per day and limited multimedia app viewing may positively correlate with preschoolers' cognitive and psychosocial development (McNeill et al., 2019).

Longer screen use (hours per day/week) was negatively associated with children's language skills, whereas higher quality use of digital devices (e.g., using educational programs or watching together with adults) was positively associated with children's language skills (Madigan et al., 2020). A longitudinal study in families of children in Taiwan showed an association between parental involvement, children's screen time, and their social competence. In children aged 3 to 5 years, parental mediation correlated positively with the children's social competence, whereas time spent by children in front of a screen correlated negatively with their social competence (Ma et al., 2022). These studies support pediatric recommendations to limit children's screen time, to choose high-quality programs, and to assure joint child–adult use of digital devices.

An association was identified by Hutton and colleagues (2022) between longer digital media use and less cortical thickness and sulcus depth in brain regions that are responsible for primary visual processing and for higher-order functions such as top-down attention, complex memory encoding, letter recognition, and social cognition. These outcomes are consistent with the findings by those researchers' earlier study of adolescents and suggest that differences in the cortical structure associated with screen use may become apparent in early childhood (Hutton et al., 2022). Digital device use for longer than the times recommended by the American Academy of Pediatrics was found to be associated with lower scores of microstructural organization and myelination of brain white matter tracts that support speech and literacy development (Hutton al., 2020).

## Discussion

Most of the featured studies are based on the evidence collected through sociological or psychological surveys of educators, parents, and teachers. The psycho-physiological approach to guidelines on the exposure to the digital environment is often neglected, as it is difficult to do such research with preschoolers. Most papers analyze "screen time," i.e., the time that the child passively perceives some content, while in fact many children actively engage with characters performing on the screen. The real screen time of preschoolers has been found to exceed recommended limits (Hu et al., 2020; Kalabina & Progackaya, 2021; Kornienko et al., 2022; Nikolaeva & Isachenkova, 2022; Soldatova & Vishneva, 2019). Surveys of preschoolers' parents showed that the time parents spent on digital devices closely correlated with their child's screen time (Lauricella et al., 2015; Lin et al., 2021).

Research shows both positive and negative effects of screen time and digital technology. It also demonstrates an association with the duration and frequency of device use. Quite often researchers do not include the positive impact of early age digital literacy in their outcome measures (Ashton & Beattie, 2019), though digital competence is seen as a key skill in the world today and is necessary for lifelong learning (Cortesi et al., 2020; Kalabina & Progackaya, 2022). An important recommendation refers to the quality of and context wherein the content is watched and whether it is discussed with an adult.

Key recommendations to parents and teachers include the reduction of total screen time for preschoolers, the use of quality content, and the adult–child joint use of digital technologies (Hill, 2016; Royal College of Paediatrics and Child Health, 2019). Despite the importance of a family's social profile and its geographical location, the recommendations are universal as they are based on the child age-related profile. However, the region of domicile (e.g., its climatic, cultural, economic, and other parameters) has an established relationship with preschoolers' screen time (Kornienko et al., 2022). Three studies indirectly support the guidelines on digital device use and screen time (Madigan et al., 2020; McNeil et al., 2019; Hutton, 2020).

Research into and discussions of the challenge with an exclusive focus on screen time seem inadequate. Today's preschoolers engage with voice assistants, smart speakers, and interactive toys connected to the internet. These tools are also part of the digital environment. The general challenge is the fast pace of technological

changes, while researchers are unable to keep up in their study of how technologies affect children (Komarova, 2022). The impact of virtual reality and immersive technologies on children deserves a separate discussion (Bailey & Bailenson, 2017), but there is not yet much data specifically on preschoolers. Compared to their older peers, young children are more likely to perceive any digital content as real, and this may influence their behavior (Richert et al. 2011).

## Conclusion

Rapid digital transformation and digital technologies that penetrate all domains of children's lives do not allow the construction of defensive strategies if they focus only on limiting the use of technology. Focusing on the influence of screen time and limiting exposure to it do not harness the digital world's benefits to stimulate preschooler development. On the whole, the data presented in the studies we reviewed enable us to describe some specifics about how cognitive abilities and their psychophysiological mechanisms develop in preschool children who have different experiences of digital socialization. However, the data is incomplete and contradictory. Nevertheless, theoretical concepts regarding critical periods in early ontogenesis, sensorimotor integration, and motor activity in the development of cognition, allow us to identify some ground rules of children's exposure to the digital environment, namely: to stay active while engaging with a digital device, to use educational applications that will develop skills appropriate to the child's age, to ensure mandatory supervision of the child's engagement by an adult who limits the exposure according to child's age-related capabilities and creates conditions for active exploration of a real rather than virtual world. Children's cognitive development suffers the most from a passive intake of digital content.

## Limitations

The study scope is limited as it describes and reviews publicly available research and full-text guidelines.

## Author Contributions

E.I. and I.K. conceived the idea. All authors discussed the results and contributed to the final manuscript. All authors selected sources for the review and equally contributed to the analysis of the sources. E.I. and I.K. contributed to the final manuscript.

## Conflict of Interest

The authors declare no conflict of interest.

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# The Relationship of Mobile-Based Social Network Addiction and Family Communication Patterns, with Behavioral Problems in Secondary School Students: The Mediating Role of Emotional Self-Regulation

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**Background**. New technologies offer endless possibilities for students and schools, but as the use of smartphones increases, psychological and behavioral problems may also increase.

**Objective**. To investigate the relationship of mobile-based social network addiction and family communication patterns on the one hand, and behavioral problems in students on the other, with a focus on the mediating role of emotional self-regulation.

**Design**. This study used a quantitative approach and a cross-sectional design. The participants were 384 students (female/male: 226/168; mean age: 16 ± 1.98) in secondary high schools in Tehran in the academic year 2022–2023. The students were selected using convenience sampling. The data were collected online using the Revised Family Communication Pattern Scale (1994), Mobile-Based Social Network Addiction Questionnaire (2016), Child Behavior Checklist — Adolescent Version (2001), and the Affective Style Questionnaire (2010). The data were analyzed using structural equation modeling with SPSS-25 and AMOS-24 statistical software.

**Results**. The study showed that emotional self-regulation plays a mediating role in the relationship between mobile-based social network addiction and internalized and externalized behavioral problems ($P \leq .05$). The indirect effect of conversation orientation on internalized and externalized behavioral problems mediated by emotional self-regulation was not significant, but the indirect effect of conformity orientation on internalized and externalized behavioral problems with the mediation of emotional self-regulation was significant ($P \leq .05$).

**Conclusion**. Based on the findings, it is suggested that school officials and parents should develop emotional self-regulation and communication skills in students and parenting skills in their parents to prevent and reduce potential harm such as internet addiction and behavioral problems in students.

*Keywords*: mobile-based social network addiction, family communication patterns, behavioral problems, emotional self-regulation

## Introduction

Smartphone addiction has intensified in recent times with the emergence of social media and networks, as this type of addiction stems from a personal desire to communicate socially (Romero-Rodríguez et al., 2020). Social network addiction is a type of behavioral addiction that adversely affects users' behavior and morals and leads to changes in adolescents' habits, lifestyles, and communication (Romero-Rodríguez et al., 2022). For example, social networks were found to increase a user's internet communication, distancing the user from their other obligations and making them reluctant to establish relationships with family and friends (Liu, Hu, & Qi, 2022). Social networks have expanded tremendously in recent years and people have easier access to these networks at any time and place through smartphones. Mobile-based social network addiction can be a risk factor for behavioral problems, especially in students (Liu et al., 2022).

Behavioral problems are abnormal behaviors that exceed the normal intensity and duration for a certain age. These problems can appear during developmental stages and can lead to serious behavioral defects and emotional problems (Yang et al., 2019). In addition to students, behavioral problems also have negative effects on their parents and teachers. These problems can be a negative predictor for students during their academic years and may turn into mental disorders in their adult lives (Gargano et al., 2023). One of the most widespread and widely accepted classifications of behavioral problems is the distinction between internalizing and externalizing problems, which has a lot of empirical support. *Internalizing problems* are individual in nature, meaning that the experience of disturbance occurs within the individual and involves problems such as depression, withdrawal, and various types of anxiety. *Externalizing problems* appear in adolescents' external behaviors, and patterns that are formed in conflict with others and include problems such as aggression or attention deficit/hyperactivity disorder symptoms (Eirich et al., 2022).

Family is another factor that may influence mobile-based social network addiction (Crespo Ramos et al., 2022). The family can be the root cause of children's behavioral problems through dysfunctional family patterns and relationships, and incorrect parenting practices (Mamsharifi et al., 2021). The family is a system whose members interact based on family communication patterns. The concept of family communication patterns refers to the way members communicate with each other and family interactions (Fitzpatrick & Ritchie, 1994). Family communication patterns involve either conversation or conformity orientations. In *conversation-oriented* families, members can freely express their opinions and attitudes. In these families, there is a high level of internal communication between the members (Campbell-Salome et al., 2019), and the children in such families are likely to experience better levels psychological well-being (Zarnaghash et al., 2013). In contrast, in *conformity-oriented* families, each member tries to force other members to follow their attitudes and beliefs. Children in these families learn to accept other people's opinions unquestioningly, and thus they develop a low level of mental health (Koerner & Fitzpatrick, 1997). One study examined academic achievement and behavioral problems in primary and secondary school students and found

that students who have close and intimate family relationships have fewer behavioral problems and, as a result, experience better academic adjustment (Smith et al., 2001).

One of the most essential skills that students must acquire for emotion and behavior control is emotion regulation (Graziano & Hart, 2016). Emotion regulation affects an individual's performance in different situations and people try consciously or unconsciously to change their desires, behavior, and emotions in a positive direction (Gross & Jazaieri, 2014). A low level of emotion regulation is one of the reasons for excessive use of the internet (LaRose et al., 2003). Emotional self-regulation affects behavior and mental functioning, and people's failure to regulate their emotions leads to emotional and behavioral problems. A recent study showed that the relationship between family functioning and social media addiction in adolescents is both directly and indirectly mediated by emotion regulation (Ghafoori & Haghayegh, 2021).

In recent years, especially due to the COVID-19 pandemic and the promotion of online education in most countries, special attention has been paid to the effect of smartphones, social networks, and mobile-based social network addiction on school staff and students. Studies have suggested that COVID-19 has adversely affected the quality of life of individuals and some feel extremely lonely, resorting to excessive use of the internet (Karakose et al., 2022a). Moreover, studies have shown that psychological distress induced by COVID-19 directly affects job burnout, depression, and addiction to social media (Karakose et al., 2022b). The decrease in students' social interactions and the increase in the time they stay at home due to the COVID-19 pandemic have increased the use of online communication tools and, as a result, the risk of developing mobile-based social network addiction (Bruni et al., 2021).

Studies that have addressed the effects of COVID-19 on mobile-based social network addiction, as well as the consequences of mobile-based social network addiction and social networks and other related factors, including family communication patterns, on students' subsequent behavioral and health problems, were either not necessarily focused on students or were not as comprehensive as the present study (Albursan et al., 2022; Erdner & Wright, 2018; Lu & Yeo, 2015; Satoorian et al., 2016; Smith et al, 2001). Furthermore, some of these studies failed to address the role of some variables (including emotional self-regulation) that can moderate and reduce the negative consequences of social network addiction and dysfunctional family communication patterns in students (Crespo Ramos et al., 2022; Mamsharifi et al., 2021). To bridge this research gap, the present study aimed to find out whether mobile-based social network addiction and family communication patterns are correlated with behavioral problems in students, using a comprehensive statistical model. The findings of this study can highlight the role of emotional self-regulation in reducing students' behavioral problems as the goal of psychological and training interventions for school counselors in working with students with behavioral problems. The findings can also enhance knowledge about the variables in question.

### Research Hypotheses and Model

- There is a significant relationship between mobile-based social network addiction and students' behavioral problems.
- There is a significant relationship between family communication patterns and students' behavioral problems.
- There is a significant relationship between mobile-based social network addiction and students' behavioral problems, with a mediating role of emotional self-regulation.
- There is a significant relationship between family communication patterns and students' behavioral problems with a mediating role of emotional self-regulation.



*Figure 1.* The hypothesized research model

## Methods

### Participants

The present study used a quantitative approach and a cross-sectional design. This fits the objectives of the study and seeks to quantify the participants' responses and describe the observed reality. The research population consisted of all secondary high school students in Tehran in the academic year 2021–2022. According to Kline (2015), the number of participants in structural equation modeling (SEM) studies should not be less than 200. According to the available statistics, the total population of high school students in Tehran is 253,398 (Statistical Center of Iran [SCI], 2021). Using Morgan's sampling table, the sample size was estimated as 384 students. Thus, taking into account the possibility of dropout, the initial sample size was considered to be 400 students, and that number of questionnaires were distributed to participants. However, after excluding incomplete questionnaires, the data from 384 students were used for analysis. The students were selected through convenience sampling due to the COVID-19 outbreak and inaccessibility of the students. A majority of participants were tenth-grade students (66.9%); 44% were studying experimental sciences; 46.4% were 16 years old; the majority were female (59%).

### Procedure

*Questionnaires*

*Child Behavior Checklist (CBCL).* This instrument was developed by Achenbach (1991) to assess behavioral problems in children and adolescents aged 11 to 18. The

checklist has 112 items that are scored on a 3-point Likert scale (0 = *absent,* 1 = *occurs sometimes, and 2 = occurs often*). The total score in CBCL ranges from 0 to 240. The checklist is one of the most widely used self-measurement tools for behavioral problems. In the original version, the researchers reported the test-retest reliability and internal consistency for behavioral problems to be .97 and .94, respectively; for externalizing behavioral problems as .94 and .92; and for internalizing behavioral problems as .91 and .90. A study in Iran reported Cronbach's *alpha* to be .83 for the whole scale and .86 and .48 for the subscales of internalizing and externalizing problems, respectively (Minaei, 2007). In the present study, Cronbach's *alpha* was .81 for the whole scale and .84 and .86 for the internalizing behavioral problems and externalizing behavioral problems subscales, respectively.

*Revised Family Communication Patterns (RFCP).* The RFCP was developed by Fitzpatrick and Ritchie (1994) to assess conversation orientation and conformity orientation. This self-assessment scale has 26 items with five options ranging from *strongly agree* to *strongly disagree*. The first 11 items measure conformity orientation and the remaining 15 items measure conversation orientation. The main developers of the RFCP have reported acceptable content, criterion, and construct validity and reliability (Cronbach's *alpha* and test-retest) for this instrument (Fitzpatrick & Ritchie, 1994). In Iran, a study reported that the reliability of this tool using Cronbach's *alpha* and the corresponding values for conversation orientation and conformity orientation were .87 and .81, respectively (Koroshnia & Latifian, 2008). In the present study, Cronbach's *alpha* for conversation orientation and conformity orientation was .89 and .84, respectively.

*Social Network Addiction Questionnaire (SNAQ).* This questionnaire was developed in Iran to measure the degree of use of social networks (Khajeahmadi et al., 2017). The first version of the SNAQ was developed with 27 items and in the psychometric analysis, one item was removed to enhance the content validity of the scale. Following the exploratory factor analysis, the number of items on the questionnaire was reduced to 23. The scale used in the present study has 23 items that measure four factors: individual performance, time management, self-control, and social relations. The internal consistency of the SNAQ was confirmed with Cronbach's *alpha* of .92. Overall, the scale has acceptable content, face, and criterion validity (Khajeahmadi et al., 2017). In the present study, Cronbach's *alpha* was .89, confirming the reliability of the questionnaire.

*Affective Style Questionnaire (ASQ).* The ASQ is a 20-item instrument developed by Hofmann and Kashdan (2010). The items are scored on a 5-point Likert scale from *very untrue of me* (1) to *very true of me* (5). The ASQ has three subscales (concealing, adjusting, and tolerating), each with 8, 7, and 5 items, respectively. All items are directly and positively scored. In Iran, a study reported Cronbach's *alpha* values for the subscales of adjustment, concealing, and tolerance as .70, .75, and .50, and the total reliability as .81. Overall, the construct validity indices for the three subscales were acceptable (Karsheki, 2013). In the present study, Cronbach's *alpha* was .86 for the whole scale and .75, .80, and .56 for the adjustment, concealing, and tolerance subscales.

After receiving the required permits from the university and the Department of Education of Tehran Province, the researcher contacted the intended schools and provided the principals with information about the objectives and significance of the study and the research procedure. Since this study was conducted during the CO-VID-19 pandemic and school closures, the online link of the instruments with some instructions about the completion of the questionnaires and ethical considerations were submitted to the students in the form of audio files and text messages, through the students' education application (Shad; A government platform in Iran used in schools during the COVID-19 outbreak) and WhatsApp messenger. To comply with the ethical protocols, the students' data were kept confidential and participation in the study was voluntary. Moreover, the students could ask any question about the completion of the questionnaires. Finally, the collected data were entered into the SPSS-25 and AMOS-24 software for statistical analysis.

*Data Analysis*

The data were analyzed using descriptive statistics (standard deviation and mean) and inferential statistics (correlation analysis and SEM). Pearson's correlation test was used to examine the relationship between research variables, and the SEM was used to examine the hypotheses related to the mediating model.

**Results**

Pearson's correlation test was used to test the research hypotheses and specify the correlations between the variables. Table 1 presents the descriptive statistics for the research variables and the correlations between them. The correlation analysis shows that individual performance ($r = .39$), time management ($r = .39$), self-control ($r = .42$), and social relations ($r = .33$) have positive significant correlations with externalizing behavioral problems. Similarly, individual performance ($r = .42$), time management ($r = .39$), self-control ($r = .50$), and social relations ($r = .30$) have positive and significant relationships with internalizing behavioral problems. Conversation orientation has a significant negative correlation with externalizing behavioral problems ($r = -.38$) and internalizing behavioral problems ($r = -.45$) but conformity orientation has a significant positive correlation with externalizing behavioral problems ($r = .40$) and internalizing behavioral problems ($r = .41$). The analysis of the components of ASQ indicated that adjustment has no significant relationship with externalizing behavioral problems ($r = -.09$) and internalizing behavioral problems ($r = -.03$), but the components of concealing ($r = .25$) and tolerance ($r = .28$) have a positive and significant relationship with externalizing behavioral problems. In addition, the subscales of concealing ($r = .41$) and tolerance ($r = .35$) have a positive and significant relationship with internalizing behavioral problems (see *Table 1*).

SEM was run to find out whether the model for behavioral problems based on social network addiction and family communication patterns, with a focus on the mediating role of emotional self-regulation, fits the experimental data, as shown in

**Table 1**

*Descriptive statistics and the correlation matrix for the research variables*

| | Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CBCL | Externalizing | 1 | | | | | | | | | | |
| | Internalizing | .64** | 1 | | | | | | | | | |
| SNAQ | Individual Performance | .39** | .42** | 1 | | | | | | | | |
| | Time Management | .39** | .39** | .73** | 1 | | | | | | | |
| | Self-Control | .42** | .50** | .60** | .60** | 1 | | | | | | |
| | Social Relations | .33** | .30** | .30** | .47** | .50** | 1 | | | | | |
| RFCP | Conversation | -.38** | -.45** | -.33** | -.25** | -.35** | -.14** | 1 | | | | |
| | Conformity | .40** | .41** | .27** | .22** | .18** | .16** | -.53** | 1 | | | |
| | Adjustment | -.09 | -.03 | -.09 | -.09 | -.09 | -.00 | .04 | .03 | 1 | | |
| ASQ | Concealing | .25** | .41** | .20** | .17** | .19** | .11** | -.24** | .24** | .43** | 1 | |
| | Tolerance | .28** | .35** | .15** | .13* | .09 | .11 | -.15** | .25** | .25** | .46** | 1 |
| | M | 92.00 | 167.46 | 33.52 | 20.96 | 13.60 | 12.10 | 41.51 | 33.46 | 18.46 | 21.43 | 13.12 |
| | SD | 6.79 | 17.66 | 6.93 | 5.39 | 3.58 | 3.37 | 15.66 | 9.99 | 4.34 | 4.93 | 3.34 |

*Note. CBCL = Child Behavior Checklist. SNAQ = Social Network Addiction Questionnaire. RFCP = Revised Family Communication Patterns. ASQ = Affective Style Questionnaire. M = Mean. SD = Standard Deviation. \*\* = P < .01; \* = P < .05.*

Tables 2 to 4 and Figure 1. Table 2 shows the fit indices of the final model. Generally, each index obtained from AMOS software alone cannot confirm the fit or non-fit of the model, and these indices should be interpreted together. The values obtained for these indices confirm the goodness of fit indices of the model.

**Table 2**

*Fit indices of path analysis of the adjusted model*

| Indices | Fit indices | |
|---|---|---|
| | **Value** | **Acceptable range** |
| $\dfrac{X^2}{df}$ | 2.85 | (Gaskin & Lim, 2016) < 3 |
| RMSEA | .07 | (Gaskin & Lim, 2016) < .1 |
| CFI | .93 | (Gaskin & Lim, 2016) > .9 |
| NFI | .91 | (Gaskin & Lim, 2016) > .9 |
| GFI | .94 | > .9 |

*Note. RMSEA = Root Mean Square Error Approximation. CFI = Comparative Fit Index. NFI = Normal Fit Index. GFI = Goodness of the Fit Index.*

**Table 3**

*Indirect effect of family communication patterns and mobile-based social network addiction on behavioral problems mediated by emotional self-regulation*

| Criterion Variable | Predictor Variable | Type of Effect | B | Beta | Upper Bound | Lower Bound | Sig |
|---|---|---|---|---|---|---|---|
| | SNAQ | Indirect | .03 | .03 | .09 | .00 | .02 |
| CBCL | Conversation | Indirect | −.13 | −.03 | .00 | −.08 | .08 |
| | Conformity | Indirect | .36 | .03 | .13 | .01 | .04 |

*Note. CBCL = Child Behavior Checklist. SNAQ = Social Network Addiction Questionnaire. B = Unstandardized Coefficient. Beta = Standardized Coefficient. Sig = significance level.*

The data in Table 3 confirm the indirect effect of SNAQ on CBCL through ASQ at a 95% confidence interval ($P \leq .05$). However, the data do not confirm the indirect effect of conversation orientation on CBCL through ASQ at a 95% confidence interval ($P \geq .05$). In contrast, the findings confirm the indirect impact of conformity orientation on CBCL through ASQ at a 95% confidence interval ($P \leq .05$). Table 4 and Figure 1 display the standardized path coefficients and the adjusted models.

As can be seen in Table 4, the factor loads for all four scales are significant at a 95% confidence interval ($P \leq .05$).

**Table 4**

*Factor loads of the measurement models*

| | Variables | Standardized Weight | T | Sig |
|---|---|---|---|---|
| SNAQ | Individual Performance | .81 | – | – |
| | Time Management | .84 | 17.11 | .001 |
| | Self-Control | .76 | 15.48 | .001 |
| | Social Relations | .52 | 10.15 | .001 |
| ASQ | Adjustment | .43 | – | – |
| | Concealing | .96 | 6.26 | .001 |
| | Tolerance | .96 | 6.26 | .001 |
| CBCL | Externalizing | .75 | – | – |
| | Internalizing | .86 | 13.94 | .001 |
| Conversation | Item 1 | .49 | 10.38 | .001 |
| | Item 2 | .70 | 16.52 | .001 |
| | Item 3 | .78 | 19.32 | .001 |
| | Item 4 | .74 | 17.81 | .001 |
| | Item 5 | .64 | 14.47 | .001 |
| | Item 6 | .74 | 17.93 | .001 |
| | Item 7 | .78 | 19.40 | .001 |
| | Item 8 | .84 | 22.00 | .001 |
| | Item 9 | .81 | 20.51 | .001 |
| | Item 10 | .80 | 19.19 | .001 |
| Conformity | Item 11 | .80 | 20.12 | .001 |
| | Item 12 | .68 | 15.61 | .001 |
| | Item 13 | .79 | 19.85 | .001 |
| | Item 14 | .82 | 20.89 | .001 |
| | Item 15 | .86 | – | – |
| | Item 16 | .40 | – | – |
| | Item 17 | .49 | 6.54 | .001 |
| | Item 18 | .69 | 7.54 | .001 |
| | Item 19 | .78 | 7.81 | .001 |
| | Item 20 | .66 | 7.42 | .001 |
| | Item 21 | .54 | 6.87 | .001 |
| | Item 22 | .47 | 6.38 | .001 |
| | Item 23 | .87 | 8.05 | .001 |
| | Item 24 | .68 | 7.05 | .001 |
| | Item 25 | .58 | 7.08 | .001 |
| | Item 26 | .58 | 7.08 | .001 |

*Note. CBCL = Child Behavior Checklist. SNAQ = Social Network Addiction Questionnaire.*
*ASQ = Affective Style Questionnaire. T = Critical Ratio. Sig = significance level.*
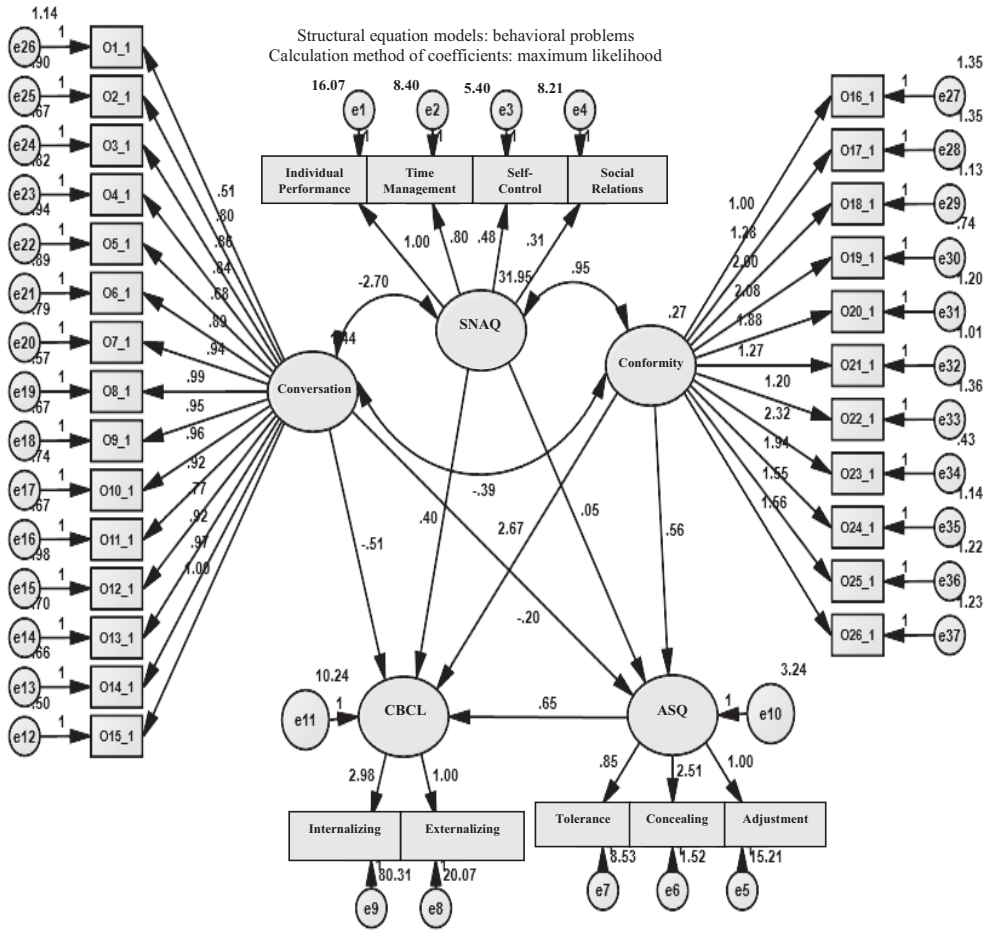
*Figure 2.* The adjusted model with standardized coefficients

*Note. CBCL = Child Behavior Checklist. SNAQ = Social Network Addiction Questionnaire.*
*ASQ = Affective Style Questionnaire.*

## Discussion

The present study investigated the relationship between mobile-based social network addiction and family communication patterns on the one hand, and behavioral problems in secondary school students on the other, with a focus on the mediating role of emotional self-regulation. The results of the correlation analysis showed that individual performance, time management, self-control, and social relations have a positive and significant relationship with externalizing behavioral problems and internalizing behavioral problems, as confirmed in previous studies (Albursan et al., 2022; Elhai et al., 2016; Whang et al., 2003). Studies on users' psychological characteristics have confirmed the relationship between depression and anxiety on the one hand, and problematic smartphone use on the other (Elhai et al., 2009). Other studies

have found that internet addicts have a higher degree of loneliness and depression than non-addicts (Whang et al., 2003). Smartphone addiction was also associated with poor quality of life and academic procrastination in students (Alburtsan et al., 2022). These findings confirm a significant relationship between mobile-based social network addiction and behavioral problems in students.

The possible negative effects of the use of social networks on mental health and behavioral problems in users can be discussed from two perspectives: form and content. The form refers to excessive use of the internet, which leads students to distance themselves from most areas of real life. As a result, the students tend to experience symptoms of depression due to lack of sleep and feelings of loneliness, shame, and fatigue. Mobile-based social network addiction also causes a person to avoid social responsibility, isolate themselves, lose social support, become ineffective and perform poorly in school, all contributing to the exacerbation of behavioral problems in students (Sujarwoto et al., 2023). Two effective mechanisms can account for the impact of the content. The first is the cacophonous input (Ellison et al., 2007). Uncontrolled content that may be full of negative news, fake news, hoaxes, extortion, and cyber harassment leads to anxiety, frustration, and damage to mental health. Another mechanism is envy (Jordan et al., 2011). Social envy is a common feature of online social media. In social networks, students often compare themselves to others who may have a higher social and/or economic status. This psychological behavior may lead to decreased well-being as students feel inadequacy or failure in the online social community. This psychosocial mechanism is supported by the social rank theory of depression, which suggests that low self-concept is associated with depressive symptoms and suicidal risk (Sturman, 2011).

The results of correlation analysis in our study showed that conversation orientation has a negative and significant relationship with externalizing behavioral problems, but conformity orientation has a positive and significant relationship with externalizing behavioral problems. Moreover, conversation orientation has a negative and significant relationship with internalizing behavioral problems, while conformity orientation has a positive and significant relationship with internalizing behavioral problems. These findings are in line with previous studies (Crespo Ramos et al., 2022; Rueter & Koerner, 2008). Accordingly, we can argue that there is a significant relationship between family communication patterns and behavioral problems in students. One study showed that adopted adolescents in families with a more conformity orientation were significantly at a greater risk of adjustment problems (Rueter & Koerner, 2008). The authors stated that conversation orientation and conformity orientation determine the extent to which family members talk about and share their thoughts and feelings. Adolescents in conversation-oriented families who are more compatible with family members are approved by their parents and follow their parents' demands, so behavioral problems are rarely seen in such families. However, people in families with conformity orientation have poor relationships. Instead of encouraging interpersonal skills and self-expression, they limit themselves to strict norms and a homogenous culture. Thus, behavioral problems will be more probable in such families (Fitzpatrick & Ritchie, 1994; Rueter & Koerner, 2008).

The data in the present study showed that emotional self-regulation plays a mediating role in the association between mobile-based social network addiction and behavioral problems, as evident in the literature (Mascia et al., 2020; Prado Gascó et al., 2018). These studies have demonstrated that people who can express and regulate emotions perform better psychologically and socially and have a high level of well-being (Prado Gascó et al., 2018). Bandura's social cognitive theory (1986) defines self-regulation as self-observation and monitoring of feelings and behaviors. In accounting for the relationship between mobile-based social network addiction and behavioral problems, studies have focused on the suppression mechanism as one of the ineffective strategies that cause anxiety (Elhai et al., 2016). Individuals who continuously and addictively use smartphones tend to suppress negative emotions related to the real world, and as a result, by drowning in the internet, they show more weakness and anxiety in real relationships. By taking refuge in smartphones, they find an opportunity to regulate their suppressed emotions, and this vicious cycle constantly repeats itself (Hoffner & Lee, 2015). In contrast, individuals who reevaluate their emotions and behaviors have less problematic smartphone use and better real-life relationships (Elhai et al., 2016).

The findings of the present study also indicate that family communication patterns associated with conformity orientation have a significant and indirect impact on behavioral problems through emotional self-regulation, as reported by Xin et al. (2018). Lackova Rebicova et al. (2020) examined the relationship between adverse childhood experiences (ACEs) and emotional and behavioral problems and concluded that difficult communication or a complete lack of communication due to the absence of the mother and father increases the likelihood of emotional problems (Lackova Rebicova et al., 2020). Xin et al. (2018) showed that dysfunctional family communication patterns, including conformity orientation, are one of the risk factors for internet addiction. Indeed, adolescents with high self-regulation problems turn to online social networks more often due to their inability to establish social relationships in the real world. Furthermore, anxiety and emotional dysregulation cause adolescents to fail to establish effective relationships with other people. Thus, they try to compensate for their ineffective real relationships by taking refuge in mobile phones and joining online social networks, and as a result, they become dependent on and addicted to these networks and tend to conform to peers (Spratt et al., 2012).

## Conclusion

The results of the present study showed that emotional self-regulation plays a mediating role between mobile-based social network addiction and behavioral problems and between conformity orientation and behavioral problems. Emotional self-regulation is considered a factor effective in promoting students' mental health and can help them avoid problematic behaviors through continuous review and control over their cognitive, emotional, and behavioral processes. While other studies (e.g., Crespo Ramos et al., 2022; Kim et al., 2009) on the negative consequences of social network addiction and dysfunctional family communication patterns have reported numerous findings, these studies have not necessarily introduced mechanisms that moderate and reduce these consequences and negative effects. The present study

investigated the simultaneous effect of mobile-based social network addiction and family communication patterns on behavioral problems in students and showed that emotional self-regulation can be an effective mechanism in modulating and reducing behavioral problems in students. Thus, the present study provides new insights into the role of emotional self-regulation in moderating and reducing students' behavioral problems. Given the gap in the literature, future research can provide more evidence for the role of emotional self-regulation in reducing behavioral problems that result from various emerging types of mobile-based social network addiction, including cyberloafing, computer game addiction, social network addiction, as well as interactive and negative parenting styles and patterns in families.

## Theoretical and Practical Implications

### Theoretical Implications

The findings of the present study concerning the relationship of mobile-based social network addiction and family communication patterns with behavioral problems in high school students, with a focus on the mediating role of students' self-regulation, can be interpreted using Davis's (2001) cognitive-behavioral model. According to this model, cognitive reasons and psycho-social health reasons can account for behavioral problems. While distorted cognitions (e.g., poor emotional self-regulation or low self-efficacy) cause many behavioral problems, poor psychosocial health (e.g., loneliness and interpersonal hostility) may be induced and worsened by mobile-based social network addiction and dysfunctional family communication patterns. They can also increase the individual's vulnerability to behavioral problems and contribute to developing negative health consequences. According to this model, cognitive factors play a central role in behavioral problems. Thus, in line with the findings from the present study, students who suffer from behavioral problems due to mobile-based social network addiction or dysfunctional family communication patterns, such as conformity orientation, also have poor emotional self-regulation. Accordingly, promoting emotional self-regulation will probably lead to a decrease in behavioral problems in students (Yu et al., 2016). Empirical evidence supports the potential effects of cognitive and psychosocial health factors on mobile-based social network addiction (e.g., Kim et al., 2009; Wu et al., 2013).

### Practical Implications

First, school officials and counselors should consider the consequences of mobile-based social network addiction, as this type of addiction affects not only the students themselves, but also the academic performance and overall atmosphere of the school and all its students. Thus, school officials and counselors should hold workshops and preventive training programs for students. Such programs can contribute to strengthening social relationships (e.g., with teachers or classmates), and providing an environment where these students feel supported and valued. Second, self-regulation is a cognitive approach to controlling social network addiction and avoiding negative consequences related to it (Ho and Yang, 2018), and it can also contribute to reducing the negative effects of family communication patterns (Ghafoori & Haghayegh, 2021).

Individual and group counseling sessions can be arranged at regular intervals to maintain students' self-regulation. Research has shown that self-regulation plays an important role in achieving academic and personal goals, more than anything else (Gollwitzer & Sheeran, 2009). As a result, psychological and motivational training courses can help strengthen students' self-regulation skills to deal with difficult situations.

## Limitations

This study has some limitations. First, the use of self-report instruments could affect the quality and validity of the participants' answers. Second, the study was conducted based on cross-sectional data that might restrict causal inferences. Third, since the study was conducted during the COVID-19 pandemic, when schools were closed, the researcher was forced to distribute the questionnaires online. Accordingly, replicating similar studies with experimental and causal-comparative methods, especially by controlling the gender of students, can provide more reliable results.

## Ethics Statement

This article is an excerpt from the master's thesis of the first author and all its steps have been reviewed and approved by the Vice-Chancellor of Research and Technology at Kurdistan University. Participation in this study required informed consent from all participants. Principles of the Helsinki Convention were also observed.

## Author Contributions

M.F. and M.R. conceived the idea. M.R. developed the theory and performed the computations. M.F. verified the analytical methods. Both authors discussed the results and contributed to the final manuscript.

## Conflict of Interest

The authors declare no conflict of interest.

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# Personal Exposure to Social Media and Variations by Gender among Cuban Youth

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**Background.** Personal exposure is a crucial aspect of digital socialization. It pertains to the amount of time spent on social networks, the number of active accounts, interactions on different platforms, the content published on social networks, the purpose for which the content is shared, the degree of personal exposure, and the changes in social life caused by the exposure. Gender plays an important role in predicting online behavior, but previous studies have yielded contradictory results.

**Objective.** To characterize personal exposure to social media in young Cubans (networks used, hours of exposure, published content, how much of one's private life is exposed, alterations due to its use). To define the differences in personal exposure based on the gender variable.

**Design.** A survey specifically created for this research was used. The sample was composed of 3345 young Cuban residents between 18 and 35 years old.

**Results.** The young people spent a considerable amount of time per day on WhatsApp, Instagram*, and Facebook/Messenger*. Users shared content related to humor, music/art, and their personal lives. These interactions served as a source of entertainment, a means of communication and socialization, and a platform for expressing opinions on various topics. Personal content was shared frequently. The young people reported experiencing disturbances such as family demands, decreased attention span, difficulty sleeping, and decreased social interactions. There were gender differences in the level of personal exposure, with females reporting higher levels of exposure.

**Conclusion.** There are high levels of personal exposure among Cuban youth. Different qualities are manifested according to gender. Females reflect the highest levels of personal exposure.

*Keywords:*
digital socialization, personal exposure, youth, social media, disorders

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* — Activities of Meta Platforms Inc. (Facebook and Instagram), and the X Corp. (as the successor of Twitter Inc.), are prohibited in the Russian Federation.

## Introduction

The use of digital technologies, particularly social media, is steadily increasing across all age groups, especially among the youth (Chaffey, 2016; Koç et al., 2019). Social media provides young people with a sense of freedom to express themselves, a platform to make new friends and maintain regular contact with them, and an opportunity to create different communities.

Digital socialization refers to the process of socialization that occurs through technological means such as online platforms (Soldatova et al., 2020). It involves the acquisition of social experiences and the transmission of social identity, which includes traditions, culture, and social roles. Personal exposure is an essential dimension of this process, which refers to the sharing of personal life and intimacy on digital platforms, such as photographs, videos, and opinions. The following parameters can be used to analyze digital socialization: hours spent on social networks; number of active accounts; interactions on different platforms; content published on social networks; the purpose for which content is shared; the degree of personal exposure; the level of concern about one's projected image on digital media; and alterations in social life as a result of the exposure.

Digital socialization is a socialization mediated by the available technological processes and constituting the appropriation of social experiences acquired online (Soldatova et al., 2020). It is a phenomenon with both an individual and social character; it enables the transmission of a social identity — *i.e.,* tradition, culture, and social roles — among other things (Balea-Fernández, 2021). Personal exposure is one essential dimension of this process.

Social media, like other spaces of primary socialization, has a significant impact on the process of personality formation and a person's worldview. However, social media differs from other social spaces in various ways. For instance, it offers immediacy, allowing users to communicate with several people simultaneously while carrying out daily tasks. Social media also provides the ability to view and share private information beyond one's immediate circle, anonymity when desired, new codes of nonverbal communication, and ways of expressing emotions symbolically. However, it can give users a false sense of control over the situation and lead to the user losing a sense of time (Hodkinson, 2017; Marder et al., 2016; Santos, 2018; Pashkovsky, 2019; Prete & Redon, 2020). Social media is a new form of existence in time and space, with peculiarities concerning the configuration of identity, subjectivity, and forms of relationship.

Various studies which have explored the utilization of digital technologies among young adults, have found that these users are highly and consistently engaged with social media platforms. These results are indicative of significant cultural transformations, which are characterized by the wide-ranging adoption of digital technologies (Abi-Jaoude et al., 2020; Cantor-Silva et al., 2018; Goodyear & Armour, 2019; Golovchin, 2022; León et al., 2022; Prete & Redon, 2020).

Understanding people's online activities and their consequences is crucial. Online behavior can be directed towards various activities such as acquiring information, reading news, enhancing personal growth, socializing, entertainment, shopping, and playing games with different levels of intensity (Mude & Undale, 2023; Ryan et al.,

2014; van Deursen & van Dijk, 2014). Gómez (2020) proposes four techno-social dimensions that mediate this process: motivation, degree of formality, degree of sociality, and type of technological domestication.

Personal data is becoming increasingly relevant and frequently shared, which raises an important issue. There are different consequences, especially for the child and youth population. Exposure to curated content may create an unrealistic view of others' lives, leading to feelings of inadequacy or low self-esteem. Reduced face-to-face interactions, increased screen time, and sedentary lifestyles may result in issues like eye strain, poor sleep quality, and validation-seeking behavior. Additionally, loss of personal privacy may potentially expose individuals to various risks, which can impact mental health. And these are only some of the potential problems. (Abi-Jaoude et al, 2020; Allahverdi, 2022; Beyens et al., 2016; Boer et al., 2022; Munar, 2010; Onete et al., 2020)

Different people interact online in different ways. Studies on the digital divide have shown that people from different genders, age groups, educational backgrounds, and experiences use the Internet in different ways. Among these factors, gender has been found to be a particularly important predictor of online behavior (van Deursen & van Dijk, 2014).

Studies have shown that men tend to spend more time on social media compared to women. However, the differences are not limited to the amount of time spent on social media, but also to the effects the exposure has on them. Despite women spending less time on social media, it has a greater impact on their academic performance compared to men. (Ali et al., 2021; Alnjadat et al. 2019; Liu, 2018; Schodt, 2021). In contrast, other studies point to greater use by women of Snapchat, Facebook*, and Instagram*, as well as a greater focus on maintaining and building a wider network of contacts, while men move more toward other digital spaces such as video games (Allison et al., 2017; Kasahara et al., 2019; Metastasio et al., 2016).

Research on the topics mentioned above is growing, but still scarce in Cuba, which presents a unique context. Mobile data usage in the country was limited until December 2018, when it was activated for general use in a limited way. However, it only became widespread and more affordable during the COVID-19 pandemic. Over time, there has been a steady increase in Internet penetration of the population, which currently stands at 68%, mostly through cellular telephony. This accelerated process, in a short period, makes Cuba a unique case, but one that can provide significant information. What are the characteristics of social network exposure of young Cubans? Is it similar to or different from that of other contexts?

The aim of this study was to analyze the personal exposure of young Cuban individuals to social media in the period from May to July 2022. The study focused on how gender influenced the understanding of this process and primarily analyzed the levels of personal exposure.

*Hypothesis 1*: It is hypothesized that there are high levels of personal exposure, which show up in the amount of time young people spend on social networks daily, the content they publish about their private lives, and the negative impact on their social life.

*Hypothesis 2*: Personal exposure varies based on gender. There are specific differences in the content males and females tend to publish, their motivations for it, and

the time they spend on social networks. These differences are influenced by social and cultural factors, and result in varying levels of personal exposure for males and females.

## Methods

### Participants

A sample of 3,345 young people was assembled in a non-probabilistic manner by quotas. A specific number of participants per province was defined, calculated so as to be representative of the population, as indicated by the data obtained by the Oficina Nacional de Estadística e Información (2022). Based on this analysis, a distribution by cluster was made, so that the sample was calculated with 99% representativeness and a 4% margin of error.

The ages of the subjects in the sample ranged from 18 to 35 years, because that is the period that is understood in Cuba to comprise Youth (M = 22.6, SD = 4.0); 63.3% were females and 36.7% were males.

### Instruments

The research relied on a quantitative methodology, with a comparative and exploratory approach. This methodology was chosen to gather comprehensive and wide-ranging data on the phenomenon across the country. The authors of the research created a survey that was not subject to validation since it was designed to collect global information on the investigated phenomenon, rather than to standardize it.

The survey had 10 questions: one on sociodemographic data; a closed question on time spent on social networks; five multiple-choice questions that explored the users' networks, content posted, purpose, and alterations; and a Likert-type scale question, which explored concern for personal image (see Appendix).

### Procedure

The data collection process consisted of two phases. The first phase involved a pilot test which was administered to 60 people. Based on their feedback, some questions were modified and others were converted into closed-ended questions, resulting in the final version of the survey. In the second phase, a survey was conducted online between May 23 and July 6, 2022. It was disseminated through various digital channels using the snowball method to reach a wide audience.

A study was conducted using 100 questionnaires to compare the results obtained through face-to-face interviews, digital surveys, and self-administered surveys. The study found that there were no significant differences in the results between the online and self-administered surveys, and the face-to-face interviews.

Data analysis was carried out using the Statistical Package for Social Sciences IBM SPSS V22. To test Hypothesis 1, descriptive statistics such as frequencies and means were used; for Hypothesis 2, nonparametric tests like Chi-square and Mann-Whitney U were employed. Additionally, a simple correspondence analysis was performed to investigate the relationship between social networks, type of content posted, and gender.

## Results

The study found that a vast majority of young people are extensively using digital social media. Specifically, almost all of the participants reported using social media, with more than half of them spending over five hours a day on these platforms. Moreover, a significant number of respondents were found to use social media for more than 10 hours a day. It was observed that females tended to spend more time on social media compared to males: $X^2$ (3, N = 3344) = 66.35, *p*<.001 (see *Table 1*).

**Table 1**

*Time spent on social media*

| Time spent | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | **Frequency** | **Percent** | **Frequency** | **Percent** | **Frequency** | **Percent** |
| Does not use | 9 | 0.7 | 9 | 0.4 | 18 | 0.5 |
| 1hr — 4hrs | 628 | 51.2 | 814 | 38.4 | 1442 | 43.1 |
| 5hrs — 9hrs | 477 | 38.9 | 950 | 44.9 | 1427 | 42.7 |
| More than 10hrs | 112 | 9.1 | 345 | 16.3 | 457 | 13.7 |
| Total | 1226 | 100.0 | 2118 | 100.0 | 3344 | 1000 |

Socialization through WhatsApp was shared and generalized by almost the entire sample. There was a difference according to gender in the most used networks: $X^2$ (9, N = 3344) = 528.87, *p*<.01. By comparison, females had a higher usage of Instagram*, Facebook/Messenger*, Pinterest, and TikTok/Likee, while males were more likely to use Telegram, You Tube, and Twitter* (see *Table 2*).

**Table 2**

*Social media on which they were present*

| Social media | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | **Frequency** | **Percent** | **Frequency** | **Percent** | **Frequency** | **Percent** |
| WhatsApp | 1198 | 97.7 | 2106 | 99.4 | 3304 | 98.8 |
| Instagram* | 563 | 45.9 | 1370 | 64.7 | 1933 | 57.8 |
| Facebook/Messenger* | 583 | 47.6 | 1296 | 61.2 | 1879 | 56.2 |
| Telegram | 621 | 50.7 | 704 | 33.2 | 1325 | 39.6 |
| You Tube | 433 | 35.3 | 454 | 21.4 | 887 | 26.5 |
| Twitter* | 330 | 26.9 | 322 | 15.2 | 652 | 19.5 |
| Pinterest | 112 | 9.1 | 424 | 20.0 | 536 | 16.0 |
| TikTok/Likee | 26 | 2.1 | 122 | 5.8 | 148 | 4.4 |
| LinkedIn | 28 | 2.3 | 31 | 1.5 | 59 | 1.8 |
| Total | 1226 | 100.0 | 2118 | 100.0 | 3344 | 100.0 |

The most common ways these youth were exposed to content online included chatting (70.6%), communicating stories or status updates (60.1%), reacting to posts (33.3%), posting content (24.9%), leaving comments (23.5%), and sharing content (21.2%). These types of interactions are typically active and short-lived, such as conversations or stories that disappear within 24 hours.

Almost all the participants reported publishing content on social media, with a majority of them sharing content related to humor, music/art, and their personal lives. The most recent content published on social media platforms was found to be associated with religion. There were noticeable differences in the content published by males and females: $X^2$ (13, N = 3320) = 668.29, p<.01. Males tended to publish more content related to humor, sports, science, and politics and were less inclined to share information about their personal lives. On the other hand, females were more likely to share content related to their personal lives, buying/selling, work/study, motivation, and fashion/trends (see *Table 3*).

**Table 3**

*Content they post about on social media*

| Content | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| Humor | 851 | 70.0 | 1313 | 62.4 | 2164 | 65.2 |
| Music/Art | 413 | 34.0 | 686 | 32.6 | 1099 | 33.1 |
| Private life | 239 | 19.7 | 767 | 36.5 | 1006 | 30.3 |
| Work/Study | 297 | 24.4 | 700 | 33.3 | 997 | 30.0 |
| Motivational | 178 | 14.6 | 552 | 26.2 | 730 | 22.0 |
| Buying/Selling | 200 | 16.4 | 503 | 23.9 | 703 | 21.2 |
| Science | 231 | 19.0 | 255 | 12.1 | 486 | 14.6 |
| Promotion | 139 | 11.4 | 304 | 14.4 | 443 | 13.3 |
| Politic | 230 | 18.9 | 194 | 9.2 | 424 | 12.8 |
| Fashion and trends | 93 | 7.6 | 301 | 14.3 | 394 | 11.9 |
| Sport | 297 | 24.4 | 95 | 4.5 | 392 | 11.8 |
| None | 91 | 7.5 | 121 | 5.8 | 212 | 6.4 |
| Religion | 45 | 3.7 | 71 | 3.4 | 116 | 3.5 |
| Total | 1216 | 100.0 | 2104 | 100.0 | 3320 | 100.0 |

There was an association between the content published and the social media platforms where the youth were most involved: $X^2$ (119, N = 3320) = 1196.27, *p*<.01. Facebook*, Instagram*, and Pinterest were more commonly associated with content about the youth's private life, buying/selling, motivation, fashion, trends, music, and art. This kind of content had a higher female audience. By contrast, YouTube, Telegram, Twitter*, and LinkedIn had more content related to sports, science, and politics, and a higher male audience.

Social media was mainly used by the participants as a source of entertainment (71.4%), a platform to share and distribute content that is of interest to others (49.9%), and a way to communicate and socialize (37.0%). Participants also used social media as a space for expressing their thoughts on various topics (32.5%) and promoting their study or work (29.7%). However, social media was rarely used for buying or selling activities, offering help, or sharing personal life details.

Participants mainly shared topics related to their friendships (49.4%), spare time (49.0%), family (38.4%), study and/or work (35.8%), personal interests (28.3%), love interest (25.7%), and socio-political activities (7.1%).

Although it is not clear why the youth shared their private lives with others, the data suggests that it happens quite frequently. Only 20% of the participants stated that they never share their private content, while almost 50% reported doing so several times a month. There were also significant gender-related differences in this regard. The data shows that females tended to share more private content than males: $X^2$ (6, N = 3344) = 122.41, $p<.01$. This indicates that people use social media to satisfy their need for recognition by sharing their private content with others. You can refer to *Table 4* for more information (see *Table 4*).

**Table 4**

*Frequency of publication of contents of private life*

| Frequency of publication about private life | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| Never | 370 | 30.2 | 328 | 15.5 | 698 | 20.9 |
| Every several months | 248 | 20.2 | 573 | 27.1 | 821 | 24.6 |
| Once a month | 121 | 9.9 | 290 | 13.7 | 411 | 12.3 |
| Several times a month | 217 | 17.7 | 511 | 24.1 | 728 | 21.8 |
| 1–3 time a week | 172 | 14.0 | 275 | 13.0 | 447 | 13.4 |
| Every day | 52 | 4.2 | 83 | 3.9 | 135 | 4.0 |
| Several times a day | 46 | 3.8 | 58 | 2.7 | 104 | 3.1 |
| Total | 1226 | 100.0 | 2118 | 100.0 | 3344 | 100.0 |

Although the respondents acknowledged that they mostly published about their private lives, the frequency of publication varied significantly. A significant portion of the sample stated that they publish about their private lives more than once a month, ranging from several times a day to several times a month. However, another group of approximately the same number of people stated that they publish every few months or never.

In general, the youth were highly concerned about the image they projected on social networks. Participants paid close attention to the content others post about them and were worried about the image they portray of themselves. Females showed more intense concern than males in these respects. These young people were also concerned about other people's comments and publications about them, albeit to a lesser extent (see *Table 5*).

**Table 5**

*Concern about the image projected on social media*

| Proposición | Male | Female | Global | U de Mann-Whitney | Sig. asintót. (bilateral) |
|---|---|---|---|---|---|
| I don't like others to post any image, comment or video of mine without consent | 3.81 | 4.03 | 3.95 | 1180915.50 | .000 |
| I select my best images to post on my profiles | 3.55 | 3.98 | 3.83 | 1097595.00 | .000 |
| I give importance to what is said about me on social networks | 2.69 | 2.73 | 2.72 | 1279414.50 | .470 |

There was a correlation between the frequency of sharing private life content and the level of concern about the image projected: $X^2$ (6, N = 3344) = 277.68, p<.01. Participants who showed their private lives less were more concerned about the publication of images without their consent.

The sample of young people in this study acknowledged the various negative effects of social media use. They reported that their families complained about the amount of time they spent online, and they themselves reported experiencing a decreased attention-span and concentration, difficulty sleeping, and less social interaction. Women who used social media more frequently showed higher levels of negative effects compared to men: $X^2$ (8, N = 3319) = 91.23, *p*<.01. It is alarming to note that 10% of the participants reported experiencing three or more of these negative effects simultaneously (see *Table 5*).

**Table 5**

*Perceived disorders resulting from presence on social media*

| Disorders | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| Family's claim for connection time | 362 | 29.9 | 839 | 39.8 | 1201 | 36.2 |
| None | 473 | 39.1 | 644 | 30.6 | 1117 | 33.7 |
| Decrease in attention and concentration | 350 | 28.9 | 673 | 31.9 | 1023 | 30.8 |
| Difficulty sleeping well | 259 | 21.4 | 513 | 24.3 | 772 | 23.3 |
| Decreased face-to-face social interactions | 240 | 19.8 | 474 | 22.5 | 714 | 21.5 |
| Feelings of anxiety, insecurity and/or distress | 195 | 16.1 | 442 | 21.0 | 637 | 19.2 |
| Social isolation | 142 | 11.7 | 318 | 15.1 | 460 | 13.9 |
| Alterations in nutritional behaviors | 72 | 5.9 | 166 | 7.9 | 238 | 7.2 |
| Total | 1211 | 100.0 | 2108 | 100.0 | 3319 | 100.0 |

It has been found that the amount of time young people spend on social media is significantly related to the development of certain disorders. As the perceived number of hours spent on social networks increases, so does the likelihood of experiencing alterations in behavior. Individuals who realize that they spend more than 10 hours a day on social media are more likely to experience a greater number of disorders. Increased exposure to social media can lead to family complaints, feelings of anxiety and insecurity, and difficulty sleeping: $X^2$ (24, N = 3319) = 560.55, p<.01.

## Discussion

The study's results support the two hypotheses. Hypothesis 1 stated that there are high levels of personal exposure among Cuban youth, which is evident in the amount of time these young people spend on social media and the content they are exposed to, especially private life content. Social media are more than just a tool for work or consumption; they are also a means of fulfilling needs, which makes young people consider them to be a space where they can express themselves and modify the forms of their relationships. Social media not only interact with content and imitate it in real life, but they also reflect people's values and lifestyles. As suggested by Prete & Redon (2020), the narrative people project online reflects subjective elements of the individual's reality.

Social media provide entertainment, and an outlet for expression, communication, content interaction, product promotion, and academic/labor activity (Abi-Jaoude et al., 2020; Candale, 2017; Colás-Bravo, et al., 2013; Domínguez & López, 2015). The expression of opinions and ideas is a crucial aspect of social media use, which satisfies the need for subjective meaning-making. Moreover, activity on the Internet contributes significantly to psychological well-being, especially when it involves interactions with others (Goodyear & Armour, 2019; Nikitina, 2021).

Young people have a tendency to showcase their private lives on social media, projecting their ways of thinking and living, which sometimes creates an idealized image of themselves. Our participants acknowledged that they tended to use social media to embellish the truth and present a perfect image of their lives. They used the platform to share their activities with others. Publishing private information not only serves as a means of expression. Rather, the online presence of an individual helps to maintain the integrity of their personality and identity in the social media realm. It also reflects the image that its creator desires to project (Pogorelov & Rylskaya, 2022).

It is important to note that the high levels of concern for one's image online can be attributed to the significant involvement and exposure of young people to social networks. Additionally, it highlights the awareness of the risks associated with the use of social media, particularly in regard to privacy issues.

Based on the results, it is evident that social media interactions are short-lived and fleeting in nature. The focus is on instant gratification and immediate responses. This type of participation and socialization carries a risk of decreasing users' levels of reflection and gradually losing track of history (Abi-Jaoude et al., 2020; Soldatova, et al., 2022).

The specific ways in which people are exposed to various environments can lead to either positive or negative outcomes, just as other social situations do. Our research highlighted the challenges involved in adapting to different social environments, which can result in significant changes, particularly at the cognitive and emotional levels.

Based on Hypothesis 2, personal exposure exhibits different characteristics depending on gender. Women tend to reflect higher levels of personal exposure, which leads to a higher degree of alteration, including family claims and decreased concentration levels. While most studies have concluded that the differences between men and women are not related to the amount of use, but to certain characteristics of such use, this study revealed a difference that goes both ways (Espinar & González, 2009; Liu, 2018).

It has been observed that women tend to use social networks more than men. They are more active in terms of publishing and consuming content related to their private life, work/study, fashion and trends, motivation, and buying/selling on platforms like WhatsApp, Instagram*, and Facebook*. They also tend to share their private lives more frequently, which makes them more concerned about the image they project. This aligns with previous studies that indicated that women use social networks more for personal care, employment, and training. Additionally, they prefer social networks that require the publication of images. However, this contradicts other studies that claim that men spend more time consuming content on social media (Valencia et al., 2020; Espinoza & Chávez, 2021).

The differences between men and women in the content they post, their motivations, and the time they spend on social media show that these digital spaces are not separate from the sociocultural context of face-to-face interactions. Gender can influence the process of socialization, leading to differences in the way people interact online. This also means that the stereotype that men are more reserved online and only interested in topics like sports, science, and politics is perpetuated.

This information is very relevant both theoretically and practically. These results are very similar to those from contexts with different social, economic and political organizations. They were obtained after only five years of mobile data use. Also, they occurred in a context of limited digital socialization due to issues of access to certain platforms and still limited connectivity. This speaks to the depth of the impact of digital socialization on social networks and the challenges they present in the globalization of living standards and relationships. Therefore, these results are in themselves relevant.

## Conclusions

There is a trend of overexposure to social media interactions, mostly on WhatsApp, Facebook*, and Instagram*. People engage in discussions about humor, music/art, and their personal lives, such as friendships, free time, and family. This is mainly done using images and memes through ephemeral interactions. The participants are highly concerned about the image they project and tend to share a lot of their personal life, which leads to various disturbances in their daily life, such as family issues

and decreased attention span and concentration. Females tend to share more of their personal lives, leading to higher levels of personal exposure.

The exhibition of private and intimate life on the Internet reflects the attempt to be part of cyberspace, and affects the balance between face-to-face and virtual socialization spaces. This translates into alterations in social life, which, in turn, can expose youth to online risks to a greater extent. Therefore, it is necessary for future studies to analyze the phenomenon from a mixed or qualitative methodology that allows researchers to deepen our understanding of the ways in which young people are exposed to social networks, and their affective, cognitive, and behavioral impact, as well as to analyze the possible online risks that may result from such levels of exposure.

## Limitations

The main limitation of this study lies in the data collection procedure. Methodologically, it was carried out through an online questionnaire, which introduces biases related to the possibility of generalizing the results, since this method meant we only worked with those participants who had access to the Internet. The data analysis was carried out only from a quantitative approach, which reduces the possibility of understanding the phenomenon from the experiences of the participants themselves.

## Ethics Statement

The procedure was conducted in accordance with the Ethical Principles of Psychologists in Cuba. Participants were provided with a brief description of the study and were guaranteed complete anonymity, as no identifying information was collected. They were then required to give their consent for voluntary participation by checking a box indicating informed consent. Participation was limited to individuals age 18 years and above.

## Author Contributions

J.E. Torralbas conceived of the idea. J.E. Torralbas and E. Corcho developed the theory, and performed the computations and data analysis. J.E Torralbas provided ample feedback and guidance in the capacity of a supervisor of E. Corcho's thesis. Both authors discussed the results and contributed to the final manuscript.

## Conflict of Interest

The authors declare no conflict of interest.

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# Appendix

## *Social media use questionnaire*

Age:                    Gender:

1.  **How much time do you usually spend on social media on a daily basis?**

    ___ 1hr — 4 hrs ___5 hrs — 9 hrs ___More of 10 hrs ___None

2.  **Select the three social media you use most often**

    ___ Whatsapp       ___ Telegram       ___ Pinterest       ___ TikTok/Likee       ___ Instagram*
    ___ Facebook*      ___ Twitter*       ___ Youtube        ___ LinkedIn

    **How do you usually interact in those social media?**

    ___ Likes          ___ Stories/States  ___Sharing
    ___ Comments       ___ Posting         ___Chat

3.  **What contents do you usually publish on social media?**

    ___ Humor          ___ Scientific/technical   ___ Promotion/outreach   ___ Work/study
    ___ Political       ___ Fashion/trends         ___ Motivational         ___ Sports
    ___ Buy/sell        ___ Private life           ___ Music/arts           ___ Religion
    ___ None            ___ Other

    **How you publish?**
    ___Videos          ___Memes           ___Texts            ___Others
    ___Pictures        ___Links           ___Audios

    **For what purpose do you publish content on social media?**

    ___ Entertainment                              ___ Buying/Selling ___Communication/So-cializing
    ___ Sharing/Disclosing content of interest
       to others                                   ___ To express my opinion on various topics
    ___ Promotion related to work and/or study
    ___ To let others know about my private life    ___ Giving help
                                                   ___ Other

4.  **What content of your private life do you usually publish on social media?**

    ___Family                     ___Friendships
    ___Couple                     ___Personal interests
    ___Free time and entertainment  ___I do not publish about my private life
    ___Socio-political activity    ___Others
    ___Study/work

**How often do you publish content related to your private life?**

___ Several times a day     ___ Several times a month     ___ Every few months
___ Every day               ___ Once a month               ___Never
___ 1–3 times a week

5.  **Have you felt that some of these situations have happened to you, following the use of social media?**

___ Difficulty sleeping well

___ Changes in eating habits

___ Social isolation

___ Decrease in face-to-face social interactions

___ None

___ Feelings of anxiety, insecurity and/or anguish when I do not use social media

___ Decreased attention and concentration

___ Complaint from my family for being connected for a long time

6.  **In what sense these statements describe you. Mark between 1 and 5, where 1 is Not at all agree and 5 is Strongly agree.**

___ I select my best images to post.

___ I do not like others to post any image, comment or video of me without my consent.

___ I give importance to what people say about me on social media.

## *Social media use questionnaire (original version in Spanish)*

### Datos generales

Edad:                              Género:

**1. ¿Cuánto tiempo empleas usualmente en las redes sociales durante un día?**

___ 1hr a 4 hrs ___ De 5 hrs a 9 hrs ___ De 10 hrs en adelante ___ Ninguna

**2. Selecciona las tres redes sociales que emplees con más frecuencia**

___ Whatsapp       ___ Telegram       ___ Pinterest       ___ TikTok/Likee __ Instagram*
___ Facebook*      ___ Twitter*       ___ YouTube         ___ LinkedIn

**¿Cómo usualmente interactúas en ellas?**

___ Likes          ___ Stories/States ___ Sharing
___ Comments       ___ Posting        ___ Chat

**3. ¿Qué contenidos sueles publicar en tus redes sociales?**

___ Humor          ___ Científico/técnico   ___ Autopromoción   ___ Trabajo/estudio
___ Político       ___ Modas/tendencias     ___ Motivacional    ___ Deportes
___ Compra/venta   ___ Vida privada         ___ Música/arte     ___ Religión
___ Ninguno        ___ Otros

**¿Cómo lo publicas?**

___Videos          ___Memes          ___Textos          ___Otros
___Imágenes        ___Enlaces        ___Audios

**¿Con qué propósito publicas?**

___ Entretenimiento                              ___  Compar/vender   ___Comunicación/socialización
___ Compartir contenido de interés para otros
___ Promoción relacionada con trabajo y/o        ___ Para expresar mi opinion sobre varios temas
    estudio
___ Para dejarle saber a otros sobre mi vida     ___ Dar ayuda
    privada
___Otros

**4. ¿Qué contenido de tu vida privada usualmente publicas en tus redes sociales?**

___ Familia                        ___ Amistades
___ Pareja                         ___ Intereses personales
___ Tiempo libre y entretenimiento ___ No publico sobre mi vida privada
___ Actividad sociopolítica        ___ Otras
___ Estudio/trabajo

**¿Con qué frecuencia publicas sobre tu vida privada?**

___ Varias veces en el día      ___ Varias veces en un mes      ___ Cada varios meses

___ Cada día                    ___ Una vez al mes              ___ Nunca

___ 1–3 veces a la semana

5.  **¿Has experimentado alguna de estas situaciones después del empleo de las redes sociales? Selecciona cuáles.**

___ Dificultad para dormir bien              ___ Sentimientos de ansiedad, inseguridad y/o angustia cuando no emplea las redes sociales

___ Cambios en los hábitos alimentarios

___ Aislamiento social                       ___ Disminución de la atención y la concentración

___ Disminución de la interacción social     ___ Quejas de su familia por el tiempo que dedica a las redes

___ Ninguna

6.  **¿En qué grado estas afirmaciones lo describen? Responda entre 1 y 5, donde 1 es para nada de acuerdo y 5 es totalmente de acuerdo.**

___ Selecciono mis mejores imágenes para publicar en las redes sociales

___ No me gusta que los otros publiquen alguna imagen, comentario o video mío sin mi consentimiento

___ Le doy importancia a lo que se comente de mí en las redes sociales

# Media Multitasking in Mixed Reality Learning Situations: What Determines Its Effectiveness?

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**Background.** Media multitasking (MMT) is common among adolescents, especially with the introduction of digital educational tools in mixed reality environments. However, there has been limited research on MMT in educational settings with electronic learning tools including augmented reality (AR).

**Objective.** To study MMT in conjunction with metacognition, technology attitudes, and effectiveness of learning activities for 13–14 year olds in a mixed reality learning situation.

**Design.** The experiment involved organizing learning activities in MMT format using digital tools, including AR. The MMT experimental group was given the option of searching the internet for information about a problem; the control group was given only a video, the e-textbook and AR application. Eye tracking measured task switching, while MMT efficiency was assessed by the number of completed tasks and test results. Metacognition was measured using the Metacognitive Awareness Inventory (MAI), and attitudes toward digital devices were examined using the Technology Attitudes Questionnaire.

**Results.** Most of the adolescents (80%) preferred MMT, and no significant differences in test performance were found between the groups. Multitasking correlated with better cognitive control and metacognition scores and negatively correlated with technophobia. Learning activity effectiveness in mixed reality was assessed by the number and time of fixations on tasks in conjunction with metacognition and cognitive control. Interactive digital tools in education improve learning efficiency.

**Conclusion.** Adolescents' preference for multitasking does not reduce learning productivity, but it does not guarantee success either. This suggests an internalization process of using digital technologies among adolescents. As a result, MMT may be gradually mastered as a new tool that is necessary for adaptation and success in an increasingly complex technological reality. Cognitive control and metacognitive planning significantly contribute to MMT efficiency, highlighting the importance of a conscious MMT strategy for effective learning.

**Keywords:**
media
multitasking,
effectiveness,
adolescents,
augmented
reality, mixed
reality, education,
eye tracker,
metacognition

## Introduction

Modern life is unthinkable without active use of digital technologies. Russian teenagers are often ahead of adults in their level of activity in the digital environment. In 2019, the average user activity of Russian teenagers was 4–5 hours on weekdays and 6–8 hours on weekends. Compared to 18 other European countries, this is one of the highest levels of weekday user activity (Smahel et al., 2020; Soldatova & Rasskazova, 2023).

High level of internet use defines a new trend in research: online and offline are considered not separately, but as a mixed reality — a single cyberphysical space in which they closely intertwine and interact, organizing people's daily lives in a new way (Colledani et al., 2023; Floridi, 2015; Skarbez et al., 2021). This unique situation of modern child development became the basis for the analysis of digital childhood in the socio-cognitive concept of digital socialization (Soldatova & Voyskunsky, 2021), which acts as a theoretical framework for our study. This concept is based on the cultural-historical paradigm (Vygotsky, 1960) and the cultural-activity approach developed in Russian psychology (L.S. Vygotsky, A.N. Leontiev, A.G. Asmolov, M. Cole, etc.), the theory of ecosystems by U. Bronfenbrenner (Bronfenbrenner, 1979, 2004), and the theory of expanded consciousness by E. Clark and D. Chalmers (Clark & Chalmers, 1998). The concept postulates the formation in a child of a new ecosystem, including the technosystem — a set of new cultural tools (all digital devices, digital platforms, applications, algorithms, as well as ways to use them). The technosystem, integrating with children's cognitive, personal, and social systems, mediates their development in mixed reality, transforms the psychological mechanisms of interiorization, exteriorization, and re-exteriorization, and determines the formation of a technologically expanded personality with a new digital sociality. The extended personality masters new activity formats in mixed reality, and one of the most prominent ones is media multitasking (MMT).

According to the cultural-activity approach, there is always an activity between child learning and mental development. One way of using and interacting with digital devices is through MMT. For both children and adults, this format is seen as a new digital sociality that has emerged in response to the increased demands of the environment. Empirical data show that MMT is a common activity format among adolescents (May & Elder, 2018; Soldatova et al., 2020a), which is also penetrating education.

Considering MMT as a type of multitasking involves referring to cognitive psychology, where multitasking has been viewed as simultaneous performance of two or more tasks (Cherry, 1953; Gray & Wedderburn, 1960; Kahneman, 1973; Pashler, 1994). MMT is defined as an activity format that involves performing multiple tasks simultaneously using digital devices. Among the approaches to the study of MMT are the successive and simultaneous approaches (Soldatova et al., 2020b). MMT is also studied as digital distraction (Aagaard, 2019).

*In-class MMT effectiveness.* Adolescents actively use digital devices during classes, which has generated much discussion among educators and psychologists (Murphy & Castel, 2023). Some researchers indicate that digital device use in school can negatively impact student achievement (Gray & Schofield, 2021; Wammes et al., 2019) as

an indicator of learning effectiveness (May & Elder, 2018; Peifer & Zipp, 2019). Effectiveness, which is also influenced by psychological and situational factors, is one of the key criteria for evaluating MMT. On the one hand, MMT creates an "illusion of productivity", which can increase motivation and positively impact outcomes. On the other hand, research shows that MMT effectiveness remains illusory (Soldatova et al., 2020b). Despite this, the ability to work with a large number of tasks simultaneously is considered an important supra-professional competence (Zeer et al., 2019). However, the modern educational system usually does not encourage students to multitask, and the pedagogical community doubts the appropriateness of developing this skill (Sidorova, 2021). Distinguishing between negative and positive MMT, researchers associate the negative one with digital distraction of students on their devices, for example, when using messengers during class (Aharony & Zion, 2019; Shane-Simpson & Bakker, 2022), and the positive one with the possibility of searching for additional information (Wu & Xie, 2018). Some studies indicate that there is no direct or indirect relationship between MMT and academic achievement in the long term (van der Schuur et al., 2019).

*MMT and metacognition.* Metacognition is the awareness of the characteristics of one's own cognition and the ability to regulate it, which determines the monitoring of cognitive processes, planning, and development of cognitive strategies, and affects productivity in general (Schraw, 1998). The regulatory component of metacognition is important in learning, as a result of which resources are allocated and concentration on meaningful tasks is achieved. The regulatory component of metacognition may be related to MMT (Soldatova et al., 2020b). In a study by Terry and colleagues (2016), it was found that students with higher metacognition preferred to multitask less, which may identify the self-regulatory nature of multitasking. MMT performance and the ability to manage it are related to metacognition (Murphy & Castel, 2023).

*MMT and cognitive control.* Cognitive (executive) control is defined as the cognitive processes that underlie voluntary behavior. Cognitive control includes inhibition (impulse and inhibitory control of automatic responses, self-regulation, and delayed gratification); shifting (task switching, mental attitude change, and cognitive flexibility); and updating (working memory operations) (Aron, 2008; Dreher & Berman, 2002). Research findings on the relationship between MMT and cognitive control are multidirectional. On the one hand, Alzahabi & Becker (2013) found a positive association of MMT with high levels of cognitive control. On the other hand, psychologists at Stanford University (Ophir et al., 2009) showed that heavy multitaskers find it more difficult to suppress irrelevant information. And Baumgartner et al. (2014) found no relationship between MMT and executive function, but multitaskers reported problems with self-regulation in everyday life when self-assessing.

*MMT and digital technology attitudes.* Involvement in MMT determines the intensity of interaction with the technosystem and is inextricably linked to attitudes towards digital technologies. People with positive attitudes tend to be more technologically equipped in their environment and, consequently, live to a greater extent in a mixed reality, which implies constant switching between different worlds. A positive relationship between MMT and technophilia as an indicator of openness and enthusiasm for using digital devices has been found in a number of studies

(Cotten et al. 2014; Ettinger & Cohen 2020). Researchers have also linked students' MMT to fear of missing out (FOMO), when a person is afraid of missing something important and constantly checks their phone (Shane-Simpson, Bakker, 2022; Terry et al., 2016).

*Digital tools in education (augmented reality — AR).* Researchers in the field of pedagogy and psychology pay attention to the use of digital technologies in the educational environment in general (Tserkovnikova & Tretiakova, 2021; Uvarov, 2018). In particular, the possibilities and prospects of mixed reality learning, using augmented or virtual reality technologies, are considered. AR technologies are becoming an educational tool, if not in schools, then in museums, encyclopedias, and individual programs. It is important to consider the opportunities that AR offers for education. Research findings show that learning in mixed reality arouses students' interest, increases their motivation and engagement in the learning process. Moreover, AR-based learning has been found to have a positive effect on learning outcomes (Maas & Hughes, 2020).

*Methods of studying MMT.* The most common instruments for studying MMT are the Media Multitasking Index (Ophir et al., 2009) and the Short Media Multitasking Measure for adolescents (Baumgartner et al., 2017). These questionnaires are based on participants' self-assessment of their media consumption patterns. However, research has shown that most users incorrectly estimate their screen time and MMT (Júdice et al., 2023; Soldatova et al., 2022). Looking for a more objective MMT assessment, we developed and tested a quasi-experimental study design that replicates the situation of everyday MMT in children and adolescents. The quasi-experiment included simultaneous performance of several tasks on a computer and a smartphone (Soldatova et al., 2020a).

*Research problem.* Digital technologies, particularly AR, are becoming more and more accessible and are penetrating the education system. This contributes to the transition of life into a mixed reality, which requires individuals to interact with the environment in new ways. One way is the MMT format, which is especially prevalent among adolescents and has become a key characteristic of today's successful person (Zeer et al., 2019). Despite the demands of the environment, school as the main socialization institution does not provide the necessary tools for the development of this soft skill, so teenagers master this format chaotically, to the detriment of their effectiveness.

The purpose of the present study was to investigate MMT features in conjunction with metacognition, technology attitudes, and learning activities effectiveness in 13–14-year-old students in a learning situation using digital tools, including AR.

*Hypotheses:*

**H1:** number and time of fixations as indicators of the task execution strategy predict the effectiveness of schoolchildren's learning activities in the MMT format.

**H2:** higher metacognition is associated with shorter fixation time on tasks and higher number of fixations.

**H3:** higher level of cognitive control is associated with less time and greater number of fixations on tasks.

**H4:** technophobia as an indicator of negative attitudes towards digital technology negatively correlates with the number of fixations and positively with fixation time.

**H5:** number and time of fixations in conjunction with high levels of cognitive control and metacognition predict the effectiveness of learning activities in the MMT format.

**H6:** the additional use of online search and an AR app in a digital learning situation enhances the effectiveness of learning activities in the MMT format.

## Methods

1. A specially designed experiment used a computer and tablet to assess behavioral features of learning task performance in MMT conditions. There were six biology tasks that took 10 minutes to complete: to find out why frogs are called cold-blooded; to study frog life-cycle stages; what helps frogs alive both in water and on land; to learn information about frog anabiosis; to study the frog skeleton and digestive system. To simulate distraction conditions in a learning situation, adolescents received an SMS during the tasks. Participants self-tracked the time at the bottom of the screen. The number and content of the tasks were selected so that they required more than the allotted time to complete. Participants were divided into two groups: experimental and control. For the experimental group, the instruction mentioned the possibility of using online search, while the control group did not. Participants received a computer with two or three windows (in the control group, windows with a video about frog anabiosis and text about amphibians from the e-textbook; in the experimental group, the same two windows and a third window with a browser for searching) and a tablet (studying the anatomy and life cycle of frogs in augmented reality) (*Figure 1*). An eye tracker was used to record the number and time of fixations on each computer window or tablet. The experiment included an observation method, which documented the adolescent's behavior in the process of performing tasks: refusal to perform tasks, overwork, etc.



*Figure 1*. Tasks on the computer and tablet

2. Two indicators were defined to evaluate MMT effectiveness: 1) the score on a control test to check the knowledge obtained during the experiment (0–9 points); 2) the number of completed tasks given in the instruction (0–5 points): watching a video, reading text, answering SMS, studying frog anatomy and life cycle in AR.

3. A structured interview with questions about attitudes toward the e-learning tools (e.g., "Did you enjoy working with the AR app?", "Which would you prefer: textbook or app?") and multitasking in education ("Would you like various lessons to be taught in a format where information could be obtained from different sources (app, textbook, video, audio lecture, notes)?").

4. A modified computerized test "Dots: Hearts & Flowers" (Korneev et al., 2018) was used to assess executive function performance.

5. Metacognition was measured using a modified Metacognitive Awareness Questionnaire (MAI) (Karpov & Skityaeva, 2005).

6. Attitudes toward digital devices were assessed using the Technology Attitudes Questionnaire (Soldatova et al., 2021).

### Participants
The study involved 64 eighth-grade students (37 girls and 27 boys) aged 13–14 from three Moscow schools.

### Materials
- Laptop computer with stimuli. Stimuli were presented on a 15.6" LED monitor with a 1920x1080 FHD resolution LCD monitor located 75 cm from the observer's head;
- A tablet with the "Froggipedia" AR program developed by Indiavidual Learning Limited;
- Eye movements during the experiment were recorded in binocular mode using a Pupil Labs Core eye tracker with a frequency of 200 Hz and < .02° resolution.

### Procedure
The study was conducted in a school or laboratory setting. First, the participant filled out a questionnaire that included sociodemographic questions, the Technology Attitude Questionnaire, and the MAI. An eye tracker was then worn and calibrated to record eye movements during the experiment. Participants received verbal and paper instructions that required them to learn the biology topics within a limited time. The experimenter emphasized that there were many tasks and only 10 minutes, and then showed how to work with the AR app. Thus, using different devices, participants had to complete several learning tasks in 10 minutes. After 5 minutes, a message with an additional task was sent to the tablet. After 10 minutes, the experimenter stopped the task, gave a 3-minute test, and interviewed the adolescents. Participants then performed the "Dots" test.

Statistical analysis was conducted using IBM SPSS Statistics v. 22 and Jamovi. Methods of descriptive statistics, F-test, correlation, regression and mediator analyses were used.

## Results

*MMT strategies and effectiveness.* The variables number and time of fixations have a negative non-linear relationship: the more fixations, the shorter their average time ($rho = -.959$; $p < .001$) (*Figure 2*). The bulk of observations are concentrated in the region of $23.52 \pm 7.81$ fixations, with an average fixation time of $28.61 \pm 12.54$ seconds (44 participants). A cluster of observations stands out, according to which participants fixated longer on tasks ($M = 104.82 \pm 21.48$ sec), making a minimal number of switches ($M = 5.8 \pm 1.14$) (nine participants). The other cluster, in the upper left corner of the diagram, also includes nine people, who were characterized by a shorter fixation time ($M = 13.26 \pm 3.65$ sec) with a greater number ($M = 46.9 \pm 7.74$).
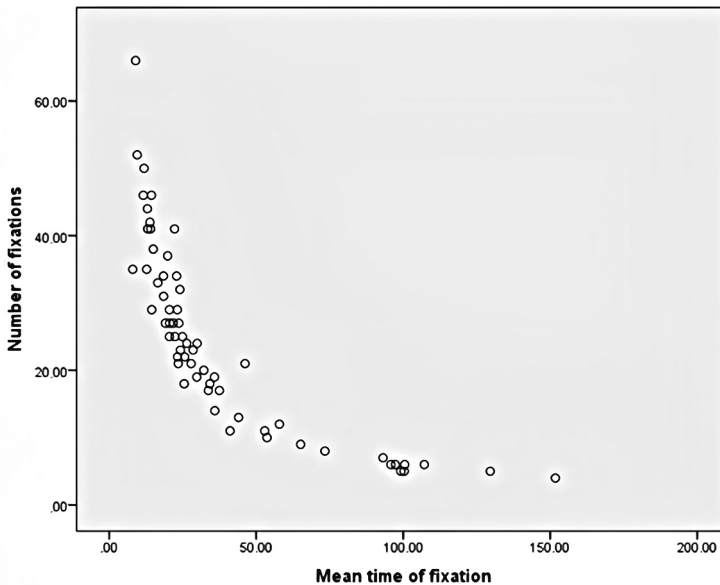


*Figure 2.* Scatter plot of the relationship between mean fixation time (sec) and number of fixations.

Group separation made it possible to assess the effectiveness of learning activities at different MMT levels; there were no significant differences.

In addition to eye tracker indicators, MMT was also considered as a digital distraction. During the experiment, only 21% of participants looked at the message sent to them and only 11% responded to the text message by performing an additional task. Texting distraction did not affect control test results (*Table 2*).

A correlation analysis of the relationship of the number and time of fixations with the MAI, Technology Attitude Questionnaire, and "Dots" test results was carried out (*Table 1*).

**Table 1**

*Correlations of mean fixation time and number of fixations with MAI, Technology Attitude Questionnaire, Dots: Hearts & Flowers (HF) test[1]*

|  | Number of switches | Mean time of fixations (sec) |
|---|---|---|
|  | *R* | |
| Information Management Strategies | .269* | −.392** |
| Regulation of Cognition | .221 | −.278* |
| Technophobia | −.151 | .278* |
| Correct answer reaction time in tries F (second trial), sec | −.224 | .386** |
| Correct answer reaction time in tries HF (third trial), sec | −.389** | .370** |
| Number of correct answers in tries HF | −.283* | .200 |
| Average reaction time, s | −.242 | .351* |
| Average reaction time in tries F, s | −.221 | .381** |
| Average reaction time in tries HF, s | −.324* | .340* |
| Correct answer reaction time, s | −.271 | .372** |
| Number of errors, Flowers (second trial) | −.330* | .407** |

*\* p < .05; \*\* p < .01*

*Cognitive control and performance strategy in learning MMT situation.* The number of fixations negatively correlated with reaction time in correct response ($r = −.389$; $p = .005$) and total reaction time ($r = −.324$; $p = .021$) in the "Dots" third trial: those who switch more had a higher level of cognitive control. There was also negative correlation between the number of fixations and the number of errors in the "Dots" second trial ($r = −.330$; $p = .018$): those who switched more had fewer errors, indicating a better ability to switch from one instruction to another. Longer fixation duration was associated with increased correct answer reaction time in the whole Dots test ($r = .351$; $p = .012$), as well as in the second ($r = .386$; $p = .005$) and third ($r = .370$; $p = .008$) trials. The same regularity was found when considering total reaction time in the whole test ($r = .351$; $p = .012$), as well as in the second ($r = .381$; $p = .006$) and third ($r = .34$; $p = .015$) trials, which may indicate a greater switching difficulty when performing two concurrent programs. In addition, longer fixation duration was positively associated with the number of errors in the second trial ($r = .407$; $p = .003$), suggesting worse cognitive control.

*Metacognition and performance strategy in learning MMT situation.* The number of fixations was positively correlated with the Information Management Strategies scale of the MAI ($r = .269$; $p = .035$) and at a sub-significant level with the Regulation of Cognition scale ($r = .221$; $p = .084$). The mean fixation time on the task was negatively correlated with the Information Management Strategies scale ($r = −.392$; $p = .002$).

[1]    Only significant correlations are shown; full table is in the appendix.

A correlation analysis between metacognition and cognitive control was also conducted. A higher score on the Information Management scale was associated with faster reaction time overall on the "Dots" test ($r = -.366$; $p = .008$) and in the first ($r = -.392$; $p = .004$) and second ($r = -.36$; $p = .01$) trials. Also at the sub-significant level, faster reaction time for correct answers in the second trial was associated with a higher total metacognition score ($r = -.249$; $p = .078$).

*Technology attitudes and performance strategy in learning MMT situation.* Mean fixation time positively correlated with the Technophobia scale (Technology Attitude Questionnaire) ($r = .278$; $p = .029$).

*Educational tools and learning efficiency in MMT.* The instruction regarding search use in the experimental group was rather flexible — it did not compel the participants to search for information on the internet, so not all of them used this opportunity. Three strategies of search use were identified: 1) supplementing the presented materials by searching for information on the internet (15 people); 2) substituting familiarization with the presented materials with searching for information on the internet (two people); 3) did not use the search (14 people). Variance analysis revealed differences in performance: those who substituted familiarity with the submitted materials with internet searches were less effective than those who used the other two search utilization strategies ($F = 3.158$; $p = .048$) (*Table 2*).

**Table 2**

*Influence of situational factors on the effectiveness of activities in MMT*

| Factor | Group | N | F | M | SD |
|---|---|---|---|---|---|
| SMS Distraction | Distracted | 13 | .013 | 5.451 | 1.76 |
| | Not distracted | 49 | | 5.385 | 1.8 |
| Online search usage strategy | Enhancement | 15 | | 4.8 | 1.76 |
| | Substitution | 2 | 3.158* | 2.5 | 0.7 |
| | Not used | 14 | | 5.533 | 1.6 |
| AR app usage | Used | 52 | 3.425 | 5.615 | 1.75 |
| | Not used | 10 | | 4.667 | 1.61 |

*\* p < .05*

The analysis of test performance depending on the use of AR showed that the majority of the adolescents chose to work with the application (78.7%) and at the trend level obtained higher test scores ($F = 3.425$; $p = .069$). These empirical facts allow us to confirm hypothesis 6.

*MMT effectiveness predictors.* A hierarchical regression analysis was applied (*Table 3*). First, the hypothesis was tested whether number and time of fixations were predictors of effectiveness in the MMT format. The constructed model showed no significant contribution of these factors ($R^2 = .0278$; $p = .435$) and their interaction ($R^2 = .0283$; $p = .641$) (Model 1, 2).

Next, we tested the hypothesis about the significance of MMT strategy (number and time of fixations on tasks) in combination with cognitive control and metacogni-

**Table 3**

*Regression models of predictors of learning effectiveness in the MMT format*

| Model | R² | P |
|:---:|:---:|:---:|
| 1 | .0278 | .435 |
| 2 | .0283 | .641 |
| 3 | .0692 | .179 |
| 4 | .213 | .048 |
| 5 | .214 | .086 |

tion. As an indicator of cognitive control, we took the productivity of the Dots test (total score and third trial). The MAI total score was taken as an indicator of metacognition. The regression analysis showed that the model did not explain the contribution of these factors to MMT effectiveness ($R^2 = .069$; $p = .179$) (Model 3). Further exclusion of the total metacognition score from the model and stepwise inclusion of the MAI questionnaire scales in the model showed an improvement in the model with the inclusion of the Planning scale (Model 4) ($R^2 = .213$; $p = .048$). Excluding any of the indicators from the model worsened it. Including the interaction factor of fixations number and time in the model improved the proportion of explained variance by 1%, but made the model significant at the trend level ($R^2 = .214$; $p = .086$) (Model 5). Thus, the best model of predictors of learning effectiveness in MMT format is Model 4: metacognitive planning ($\beta = -.257$; $p = .068$), cognitive control (Dots: total number of correct answers ($\beta = .686$; $p = .011$), number of correct answers in third trial (HF) ($\beta = -.613$; $p = .023$) and MMT format performance strategy (number of fixations ($\beta = -.142$; $p = .521$) and fixation time ($\beta = .154$; $p = .479$)).

**Table 4**

*Model 4: predictors of learning effectiveness in the MMT*

| Predictor | P | β |
|:---|:---:|:---:|
| Intercept | .040 | |
| Number of fixations | .521 | −.142 |
| Average fixation time | .479 | .154 |
| Dots: Total number of correct answers | .011 | .686 |
| Dots: Number of correct answers (third trial) | .023 | −.613 |
| Metacognitive planning | .068 | −.257 |

The most significant factor in MMT effectiveness is cognitive control, while metacognitive planning is significant at the trend level. The number of fixations and their average time do not have unique contributions to effectiveness, but they are related to it in a certain way together with the variables listed above.

Mediator analysis showed no significant results ($p > .05$).

## Discussion

*Performance strategies in a learning MMT situation in mixed reality.* Two small, equal groups were identified, which can be categorized as single-taskers and "heavy" multi-taskers. The third and largest group (71%) comprised adolescents who preferred such a strategy of multitasking in a learning situation, where the average number of fixations is 23.52 with an average fixation time of 28.61 seconds. We tentatively name this group "average" multitaskers (Murphy et al., 2017), as its indicators stand out when comparing it with the two extremes, "heavy" and "single-taskers", whose average number of fixations was 46.9 and 5.8, respectively, and average fixation times were 13.26 and 104.82 seconds. The results support findings on the prevalence of multi-tasking strategy among the younger generation, using it to adapt to mixed reality (Colledani et al., 2023). Adolescents more often choose "average" multitasking strategy, and the percentage of "heavy" multitaskers appears to be small, which is consistent with other studies (Soldatova et al., 2020a). In the current study, no differences in performance were found between single-taskers, "average", and "heavy" multitaskers. Similar results have been reported in other studies where multitasking preference did not always affect performance (Kirschner & De Bruyckere, 2017; van der Schuur et al., 2019). This indicates that each child intuitively chooses the appropriate degree of multitasking for him/herself depending on their abilities and resources.

*Cognitive control and performance strategies in a learning MMT situation.* Research on the relationship between MMT and cognitive control is mixed: there are results indicating rather a negative correlation between the two (Ophir et al., 2009); another study found no such correlation (Baumgartner et al., 2014), while another group of papers reported a positive one (Alzahabi & Becker, 2013; Matthews et al., 2022). Our results also demonstrated that MMT preference is associated with cognitive benefits (more developed cognitive control). In such a case, a small number of switches and long fixation time could be considered as "getting stuck" on a task. This may indicate poorer functioning of cognitive control, which is particularly involved when working in such a resource-intensive activity format as MMT.

*Metacognition and performance strategies in a learning MMT situation.* Most researchers agree that metacognition negatively correlates with MMT (May & Elder, 2018; Peng & Tullis, 2021; Terry et al., 2016). However, there are studies that have not found a negative effect of multitasking on metacognition (Konishi et al., 2020). In our study, a more multitasking learning strategy was associated with higher metacognition scores in the context of information management. Adolescents who chose a more multitasking strategy showed better skills and strategy sequences used to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing). Parry and le Roux (2019) also discussed the development of metacognition as a way to manage multitasking, but in this context, "multitasking management" is understood as reducing the degree of multitasking.

*Technology attitudes and performance strategy in the MMT situation.* Adolescents who preferred a more single-tasking performance strategy were characterized by more negative attitudes towards digital technologies. This is consistent with research findings in which greater student multitasking was associated with positive attitudes toward digital technology (Cotten et al., 2014; Ettinger & Cohen, 2020; Shane-Simpson & Bakker, 2022; Terry et al., 2016). Such results may indicate greater integration

of multitaskers into the technosystem through positive attitudes toward digital devices. Thus, MMT acts as a way to enhance the process of integration with the technosystem (Soldatova & Voyskunsky, 2021), where the real ("physical") and virtual ("digital") worlds intertwine, creating a "phygital" world in which the ability to direct one's attention to several different sources of information is essential (Colledani et al., 2023). This is also supported by research on the relationship between MMT, performance, and cognitive control at different ages: the highest MMT performance was observed among the younger generation (7–27 years old), which may be related to their MMT training due to the abundance of digital technologies accompanying their development (Matthews et al., 2022).

*Educational tools and learning activity efficiency in MMT.* According to our study, the majority of adolescents would like modern educational tools to be included in the learning process. This is consistent with results of a study on VR- and AR-technologies usage in biology lessons. The majority of participants positively evaluated the experience, noting AR's accessibility and interactivity (Garcia-Bonete et al., 2019). Our study extends the understanding of the use of digital tools in the learning environment and shows that their use as a complement to the educational process, rather than as a substitute for it, not only does not reduce the effectiveness of learning, but in some cases even improves it. This is confirmed by the higher test results of teenagers who used the AR application.

*Activity effectiveness predictors in learning MMT situation.* According to the results of our study, single-taskers and multitaskers did not differ in activity efficiency. This can be explained by the experimental instruction, which did not oblige multitasking. Adolescents independently chose their performance strategy. Kononova et al. (2016) demonstrated that being compelled to multitask leads to inefficiency. People can only be effective in MMT when they self-regulate their actions. Regulating one's action strategy is generally possible in everyday life, but is often limited in the laboratory, which may partially explain the inconsistency of our results with most studies concluding that MMT harms performance (Aharony & Zion, 2019; Gray & Schofield, 2021; Wammes et al., 2019). Those studies, however, do not always address the mediating factors that may predict MMT efficacy. In order to identify such factors, we conducted a regression analysis, which suggested that for effective work in MMT it is not so much the performance strategy (number and time of fixations) that is important, but rather a high level of cognitive control and metacognitive planning. Based on these resources, the adolescent chooses the optimal combination of the number of switches and the fixation time on each task. The most significant predictor of MMT effectiveness was found to be a high level of cognitive control. This coincides with the results of studies in which MMT is associated with better performance of executive functions (Alzahabi & Becker, 2013; Matthews et al., 2022). Along with cognitive control, metacognition plays an important role in MMT performance, which is one of the pathways (mediators) through which successful multitasking occurs (Fazeli et al., 2017). The correlation between metacognition and cognitive control, as well as their co-impact on MMT performance, suggests that the interaction between cognitive control and metacognition may be a mediating factor of MMT performance in a learning situation. It was shown that the integration of metacognition and cognitive control can improve children's perception and management of their own learning

(Marulis et al., 2020). However, our mediator analysis did not reveal such an effect, although this may be due to sample size. Further research could focus on the effects of metacognition on cognitive control and the possibility of developing metacognition to improve MMT performance in adolescents.

## Conclusion

The study showed the prevalence of a multitasking strategy among adolescents in a learning situation saturated with electronic learning tools. MMT to a greater extent was determined not so much by the activity associated with the use of digital devices, as with the need to solve different tasks under conditions of limited time resources. However, given three different styles of adolescents' organization of their learning activities in mixed reality (from minimal switching and prolonged focus on tasks to chaotic switching and short fixation on tasks), no significant differences between groups were obtained in the efficiency of solving the problems on the final test. It is possible that teenagers' preference for a multitasking strategy, on the one hand, does not harm the productivity of learning activities, but on the other hand, the choice of such a format does not lead to success. This may indicate a process of internalization of this way of using various digital technologies and tools, which is taking place at this stage among adolescents who prefer MMT. As a result, multitasking may be gradually mastered as a new tool that is necessary for adaptation and success in an increasingly complex technological reality. The success of this process supposes that the adolescent has an interest in digital devices, while technophobia may hinder it.

Cognitive control and metacognitive planning make the greatest contribution to the effectiveness of MMT activities. The results show that the productivity of learning activities can be ensured by the conscious choice of an MMT strategy that best suits each adolescent, depending on his or her cognitive and metacognitive abilities related to the voluntary regulation of activities. Focusing on the development of these two components in adolescents may allow them to cope with the intensive information flow, using digital devices and ways of interacting with them as educational tools to facilitate better learning.

## Limitations

This study's limitations include the small sample size and the narrow age range of participants (13–14 years old), which hinders generalizing the results and warrants further research across different age groups with larger sample sizes. Additionally, the absence of similar studies using AR technology in the educational MMT environment restricts the ability to compare the data with other research, leading to separate comparisons with MMT studies in education and AR in education. Lastly, the possibility that the instruction might have influenced the teenagers' choice of activity strategy is worth considering, due to its potential impact on the outcomes.

## Ethics Statement

The study and consent procedures were approved by the Ethics Committee of the Faculty of Psychology at Lomonosov Moscow State University (approval No: 2022/25).

Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## Author Contributions

G.U. Soldatova conceived of the idea and developed the theory. A.G. Koshevaya collected data and performed the computations. Both authors verified the analytical methods, discussed the results, and contributed to the final manuscript.

## Conflict of Interest

The authors declare no conflict of interest.

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# Appendix

*Correlations of mean fixation time and number of fixations with MAI, Technology Attitude Questionnaire, Dots: Hearts & Flowers (HF) test, academic performance and effectiveness*

| | Number of switchings | Mean time of fixations |
|---|---|---|
| | *R* | |
| Declarative Knowledge | .099 | −.110 |
| Procedural Knowledge | .003 | −.007 |
| Conditional Knowledge | .150 | −.095 |
| Knowledge about Cognition | .102 | −.088 |
| Planning | .102 | −.198 |
| Information Management Strategies | .269* | −.392** |
| Comprehension Monitoring | .145 | −.086 |
| Debugging Strategies | .230 | −.169 |
| Evaluation | .153 | −.233 |
| Regulation of Cognition | .221 | −.278* |
| MAI Total | .193 | −.227 |
| Technophilia | .066 | −.186 |
| Technorationalism | .099 | −.195 |
| Technophobia | −.151 | .278* |
| Technopessimism | .027 | .062 |
| Correct answer reaction time in tries H (first trial), sec | −.086 | .216 |
| Correct answer reaction time in tries F (second trial), sec | −.224 | .386** |
| Correct answer reaction time in tries HF (third trial), sec | −.389** | .370** |
| Number of correct answers in tries H | −.121 | .090 |
| Number of correct answers in tries F | .034 | −.109 |
| Number of correct answers in tries HF | −.283* | .200 |
| Average reaction time, sec | −.242 | .351* |
| Average reaction time in tries H, sec | −.080 | .209 |
| Average reaction time in tries F, sec | −.221 | .381** |
| Average reaction time in tries HF, sec | −.324* | .340* |
| Correct answer reaction time, sec | −.271 | .372** |
| Number of correct answers | −.153 | .080 |
| Number of incorrect answers | .049 | .016 |

| | | |
|---|---|---|
| Number of incorrect answers in tries H | .021 | −.059 |
| Number of errors F | −.330* | .407** |
| Number of incorrect answers in tries HF | .229 | −.149 |
| Number of missed responses | −.034 | .138 |
| Number of missed responses in tries H | −.012 | .205 |
| Number of missed responses in tries F | −.105 | .176 |
| Number of missed responses in tries HF | .012 | −.046 |
| Functional state change | −.189 | .205 |
| Mood change | −.028 | .086 |
| Academic perfomance | −.037 | .027 |
| Effectiveness | .166 | −.125 |

*\* p < .05; \*\* p < .01*

# How Does Joint Media Engagement Affect the Development of Executive Functions in 5- to-7 year-old Children?

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**Background**. Executive functions are actively developing in children of preschool age. Executive functions' development is also influenced by the way children are using digital devices. Joint media engagement is one of the parameters of digital device usage that has been poorly studied so far, although this is of great importance from the point of view of cultural-historical psychology.

**Objective**. Our research aimed to explore the association between young children's development of executive functions over a year, and their joint media engagement with parents and siblings in preschool children.

**Design**. Four hundred ninety (490) typically developing children (52% of them were boys) participated in the study. It was a longitudinal study: during the first stage, the children were 5-6 years old; the second stage followed one year later. The NEPSY-II subtests (Inhibition, Statue, Memory for Designs, Sentences Repetition) and the Dimensional Change Card Sort were used to assess executive functions. A questionnaire for mothers was used to get information about the children's joint media engagement and screen time.

**Results**. Children who watched video content and played video games together with their siblings developed more inhibitory control over the year than those children who did it alone. Co-viewing of video content with parents was associated with a decrease in cognitive flexibility over the year, as opposed to watching it alone.

**Conclusion**. The obtained data allows us to conclude that joint media engagement is important for executive functions development, and that there are optimal formats of joint media engagement. Based on the limitations of this study, recommendations for future research were suggested.

*Keywords:*
preschool age, joint media engagement, screen time, executive functions (EF), working memory, inhibition, cognitive flexibility, digital devices (DD)

## Introduction

Preschool children are actively developing their executive functions (EF) (Blair & Raven, 2015; Garon et al., 2008). EF development in the preschool period predicts successful adjustment to school and schooling, as well as life achievements, health, well-being, and quality of life in adulthood (Banshchikova et al., 2023; Robson et al., 2020; Scionti et al., 2020; Stichter et al., 2016; Vets, 2023). EF development at preschool age is influenced by the social situation of a child's development (Vygotsky, 1984), and the children's usage of digital devices is a part of that context (Kurilenko et al., 2022; Soldatova, 2018). The term "digital devices" (DD) refers to electronic devices that have a screen — possibly to be used interactively — and potential access to the Internet, namely: TVs, smartphones, computers, and tablets.

Modern preschoolers use DD for about three hours a day (Konca, 2022; Rideout & Robb, 2020), and now the connection between the features of the DD use and EF development is being actively studied. A large number of studies have shown that screen time is inversely related to the development of all EF components in preschool children, but this applies primarily to those children who exceed the daily norm for screen time (Corkin et al., 2021; Jusienė et al., 2020; Linebarger et al., 2014; McNeill et al., 2019; Nichols et al., 2022).

When assessing the potential impact of DD use on EF development, it is important to study certain aspects of digital leisure such as the degree of its interactivity; however, this aspect has so far been poorly researched. Based on the degree of interactivity experienced in digital leisure, passive and active screen time can be distinguished (Bukhalenkova et al., 2021). Passive screen time is watching video content; active screen time involves cognitive and/or physical engagement in the process of using a digital device: for example, playing video games and using mobile applications.

Another little-described aspect of preschoolers' digital experience is their joint media engagement with parents and siblings (Stevens & Penuel, 2010). Recent studies of joint media engagement have so far not dealt with the aspect of EF development (Dore & Zimmermann, 2020; Stevens & Penuel, 2010). Joint media engagement (shared DD use) includes watching video content without communicating, watching content with discussion, and joint video games, as well as the use of mobile applications (Dore & Zimmermann, 2020): that is, both passive and active screen time.

Thus, studying the joint passive and active screen time of preschoolers with their parents and siblings is important, since it can help determine the uses of DD which are most favorable for EF development (Belova & Shumakova, 2022). In this regard, the purpose of our research was to study the relationship between the development of the main components of EF in preschoolers over a year's time, and with whom children spent their passive and active screen time — with parents, siblings, or independently.

### *Executive functions development in preschool age*

Our research focused specifically on studying the influence of how DD were used on EF development, since EF are an indicator of the mastery of higher mental functions. EF are a group of cognitive skills that enable goal-directed problem-solving and ad-

aptation to new situations (Diamond, 2013; Friedman & Miyake, 2017). A. Miyake's conceptual framework identifies the following components of EF: 1) working memory (verbal and visual) — this is the ability to retain information and use it to solve current problems; 2) cognitive flexibility — the ability to switch between tasks, rules, incentives, etc.; and 3) inhibitory control — inhibition of impulsive reactions and a dominant response in favor of what is required by the context (Diamond, 2013; Miyake et al., 2000).

EF development at preschool age depends on a large number of factors. First of all, it is mediated by various parameters of the child's neurological development and his/her temperamental characteristics (Olness et al., 2009; Short et al., 2019). In addition, a sufficient quantity and quality of sleep (Kahn et al., 2021), as well as physical activity (Bai et al., 2020), are important. Second, EF development is affected by family lifestyle and parenting strategy, as well as the level of the parents' education and family income (Hackman et al., 2015; Hughes & Devine, 2019). Also, the quality of parent-child relationships is significant for EF development. A child's EF level is positively associated with the following characteristics of parental behavior: warmth, responsiveness, support, and willingness to join in the child's activities, and provide him/her with independence (Valcan et al., 2018).

Third, EF development is favored by role play (Yogman et al., 2018; Veraksa et al., 2020b; Veraksa A. et al., 2022), which is the leading form of play at preschool age (Vygotsky, 2012). Through play, preschoolers develop the ability to follow rules, develop problem-solving skills, and master the main EF components (Yogman et al., 2018). Finally, as mentioned above, EF development at preschool age can be influenced by the child's DD use, in particular parameters of use such as joint media engagement. The study of this particular parameter is of specific interest because it is a factor that parents can influence relatively easily, thereby promoting the development of a preschooler's EF (Wannapaschaiyong et al., 2023).

### EF and joint media engagement of preschoolers and their parents

Joint media engagement of children and their parents may vary depending on the parental digital mediation strategy (Ewin et al., 2020; Kalabina & Progackaya, 2022). Two main parameters of parental digital mediation are parental support and parental control (Rudnova et al., 2023). Depending on the intensity of these parameters, the relationship between the child's EF development and the joint media engagement of preschoolers and their parents may differ. On the one hand, it can be assumed that the predominance of parental support during digital mediation (information and technical assistance when using DD, discussion and explanation of the content, and emotional participation of the parent in the child's digital activity) can contribute to the development of all EF components. On the other hand, it can be assumed that the predominance of parental intrusiveness and negative control during digital mediation can lead to a slower increase in inhibitory control, because it interferes with children's own initiative (Geeraerts et al., 2021; Feng et al., 2011). However, joint media engagement of children and their parents is usually a manifestation of parental support during digital mediation, and, accordingly, should be beneficial for EF development (Wannapaschaiyong et al., 2023).

There is "high-level" and "low-level" joint family media engagement (Koran et al., 2022). "Low-level" joint media engagement is passively watching videos or playing games together without communicating or training; even this, compared to independent DD use, improves children's understanding of what they see on the screen (Dore & Zimmermann, 2020). After all, even if a parent passively watches the video next to the child, he/she can answer questions about what he/she saw and express his/her attitude towards it (Waters et al., 2016). In a study by Wannapaschaiyong et al. (2023) with the participation of 110 5-6 year-old children, it was demonstrated that, when watching video content together, all parents in one way or another initiated a discussion with the child of what they saw together.

However, of course, "high-level" — that is, active and thoughtful — joint media engagement has a greater impact on children's EF development (Dore & Zimmermann, 2020; Strouse et al., 2013). If the parent and child regularly discuss content while watching it, the negative effects of violent content on the child are mitigated; conversely, the positive effects of educational content are enhanced (Waters et al., 2016). It is important to note that most video games and mobile applications are designed to involve only one person (Dore & Zimmermann, 2020). Therefore, often joint engagement does not imply full interaction between the child and the partner, but rather observation of the partner's activities. That is, "high-level" joint media engagement often requires special efforts on the part of the parent. But it is the "high-level" joint media engagement that can contribute to the development of all components of EF, since it is a form of child-parent interaction.

Joint media engagement of children and parents or other significant adults may be associated with EF development for a number of reasons. First, parents can make decisions regarding the selection of educational video content and video games that are most suitable for the child (Dore & Zimmermann, 2020; Ewin et al., 2020). Parents can also protect their child from unwanted content and various risks on the Internet. It has been shown that the content of videos, as well as of video games, can be associated with EF development: for example, educational digital activities aimed at children can contribute to EF development, and vice versa; content that is not suitable for those of a young age and content, for example, containing scenes of violence, can negatively affect EF (Bukhalenkova et al., 2021). Second, parents or other significant adults can help the child critically comprehend the video content he/she sees and discuss with the child his/her impressions after the digital leisure (Dore & Zimmermann, 2020). That is, the joint media engagement of children and parents or other significant people is a form of live communication, and high-quality child-parent interaction which can contribute to EF development (Veraksa, 2014). Third, parents or other significant adults can monitor a child's screen time, while excessive screen time is a risk factor for EF development (Swider-Cios et al., 2023; Veraksa N. et al., 2022).

While in general the joint media engagement of preschoolers with their parents rather favors EF development, it can be assumed that there are also ways of joint media engagement that do not contribute to that positive outcome. First, if parental control significantly predominates in digital mediation, then it is likely that joint media engagement will not develop the child's EF (Geeraerts et al., 2021; Feng et al., 2011). After all, when an adult overly controls the activities of a preschooler and does not

give him/her the opportunity to take initiative, make decisions, or independently follow a plan, then the adult, as it were, takes on the role of the child's EF. Second, there is a lack of scientifically proven evidence on how to find and choose high-quality educational apps (Aleksandraki & Zaranis, 2023; Belolutskaya et al., 2023; Papadakis et al., 2021; Pesha, 2022). A study by Papadakis et al. (2022) showed that parents prefer to download free apps for children. But such apps may include advertising that overstimulates a child's attention. Also, joint media engagement may not contribute to EF development because parents do not have sufficient information on how to properly conduct digital mediation and how to talk about DD use (Papadakis et al., 2022). However, from the point of view of cultural-historical psychology, it is the child-parent interaction in the process of any activity that is important for EF development (Vygotsky, 2012). Based on this, the process of child-parent interaction itself during digital leisure is more important than choosing high-quality apps or video content. Thus, the impact of joint media engagement of preschoolers and their parents on the children's EF development may be multidirectional, and it has so far been poorly studied.

### EF and joint media engagement of preschoolers and their siblings

No studies have been found on how the joint media engagement of preschoolers and siblings is related to EF development. So far, one can only make guesses about how joint media engagement of preschoolers and siblings affects EF development.

There are studies on how the presence of siblings and joint activities with them are generally connected to EF development. The results of these studies can also be partially applied to digital leisure. Thus, the presence of siblings in itself may be associated with a higher EF level (McAlister & Peterson, 2013; Rolan et al., 2018).

There are several reasons why the presence of a brother or sister may be associated with better EF development. First, the interaction of a preschooler with an older brother or sister is a context in which a preschooler can learn, and master new skills and cultural norms, thereby also developing EF (Vygotsky, 1978). Second, cooperative play and conflicts with siblings (whether younger or older) are safe contexts for the development of various social, emotional, and cognitive skills, including EF (McAlister & Peterson, 2013; Rolan et al., 2018). Having a sibling increases the frequency and variety of situations in which a child needs to compete and make compromises, potentially promoting the development of working memory, inhibitory control, and cognitive flexibility, as well as planning and strategic thinking skills (McAlister & Peterson, 2013). Third, parental upbringing strategies may differ depending on whether there is one child in the family or several. Thus, if there are siblings, parents can pay more attention to issues of discipline, structuring children's leisure time, and introducing rules (Rolan et al., 2018), which is beneficial for EF development.

It is important to note that all these patterns apply primarily to siblings with a certain age difference. Thus, the interactions of an adolescent or adult sibling with a preschooler can resemble interactions between parents and a child, and create a social environment similar to that in which there is only one child (McAlister & Peterson, 2013). And if a preschooler has a much younger sibling, then interactions

with him/her are limited and cannot fully contribute to EF development (McAlister & Peterson, 2013).

Based on the studies described above and the logic of EF development, we can assume that watching video content together with a sibling, as well as playing video games together, develops inhibitory control. This is because the child, in the process of sharing a DD with a sibling, needs to wait his or her turn, and not interfere with the partner. Playing multiplayer video games with a sibling is likely to develop working memory, because it is necessary to retain agreements about the shared actions and wishes of the partner, as well as the partner's game actions themselves. Also, playing video games together with a sibling can help to develop cognitive flexibility because the child needs to constantly switch between two processes: communication with a sibling and the video game itself. Empirical research on this topic is required to test these assumptions.

### Our research

Despite the widespread use of DD by children, the connection between EF development and interaction with those with whom the child usually uses DD (with siblings, with parents, alone) has not been sufficiently studied. Some papers on joint media engagement of children and their parents are theoretical in nature, and there are not enough empirical studies (Dore & Zimmermann, 2020). We found no studies on how joint media engagement of children and their siblings affects EF development. But this topic is very relevant, as the senior preschool age (when interaction with other children first begins) is important for cognitive and emotional-personal development, particularly EF development (Lisina, 2009).

To fill the gap in existing knowledge, we set out to study the relationship between the rate of development of EF in preschool children over one year (from 5 to 6 years old), and the characteristics of joint media engagement of children and their parents and siblings. The following research questions were formulated:

1. How is the joint media engagement of preschoolers and their parents related to the development of various components of EF over one year?
2. How is the joint media engagement of preschoolers and their siblings related to the development of EF's various components over one year?

At the same time, the factor of screen time was taken into account as a parameter potentially influencing EF development (Corkin et al., 2021).

### Method

### Participants

Four hundred ninety (490) children (52% of them were boys) from municipal kindergartens in three regions of Russia took part in our longitudinal study: 35.6% of children were from Kazan, 32.5% from Moscow, and 31.9% from the Republic of Sakha (Yakutia). Seventy-four percent of the mothers had a higher education; 78% of the families had an average level income.; and 67% of the children had one or more siblings.

During the first phase of the study, the average age of the children was 5 years and 5 months (M = 65.14; SD = 5.04 months). The children were pupils in the senior groups of the kindergarten. The second phase was carried out a year later, when the children were attending the kindergarten's preparatory groups, which is the last educational stage in the kindergarten, before the children go to school.

## Materials

**To study the main EF components** (working memory, inhibition, and cognitive flexibility), we used a set of tasks which had been previously tested on a Russian sample (Veraksa et al., 2020a).

**For verbal working memory** assessment**,** the NEPSY-II subtest "Sentence Repetition" (Korkman et al., 2007) was used. The stimuli consisted of 17 sentences of increasing length and complexity. Each sentence was read out loud to a child, and then he/she was asked to repeat it immediately. Each correctly repeated sentence was scored 2 points. If the child made one or two mistakes, the response was scored 1 point; if there were three and more errors during the repetition, the sentence was scored 0 points. The exercise stopped when the child received 0 points three times in a row. Accuracy scores were also calculated (max 34 points).

**For visual working memory** assessment, the Memory for Designs subtest of the NEPSY-II (Korkman et al., 2007) was applied. This technique included four tasks; in each, the child was presented with a grid (a field 4 by 4 with 16 cells) where several (from 4 to 8) color pictures were located in different cells. The child was shown a picture for 10 seconds, and then the picture was taken out of sight. The child then had to select the patterns from a set of pictures and place them in a grid in the same place they were shown earlier. The child had to complete four tasks. For each task, points were scored on four indicators: 1) the Content Score evaluated the child's ability to remember image details (to choose those pictures that were in the example, not distractors); 2) the Spatial Score evaluated the child's ability to remember the location of objects (to place the cards in the correct cells on the grid); 3) the Bonus Score reflected the child's ability to correctly reproduce the entire visual image (put the correct cards on the right places on the grid); and 4) the Total Score was the sum of the three previous indicators (max 120 points).

**For cognitive inhibition** assessment, the Inhibition subtest of the NEPSY-II (Korkman et al., 2007) was used. The subtest included two series of black and white pictures: a series of figures (circles and squares) and a series of differently directed (up and down) arrows. Two tasks were required with each series of pictures: 1) the Naming task (a child had to name the figures that she/he saw as quickly as possible) and 2) the Inhibition task (a child had to say the opposite of what he/she saw: for example, if she/he saw a circle, she/he had to say "square"). Three metrics were analyzed in each task: 1) the number of uncorrected errors which occurred when the child did not correct the mistakes made; 2) the number of self-corrected errors which occurred when the child at first gave the wrong answer, but then corrected himself/herself; and 3) the time that it took the child to name all the figures. These three scores were then converted into a combined score using special tables from the NEPSY-II manual (from 1 to 20 points).

**For physical inhibition** assessment, the Statue subtest of the NEPSY-II (Korkman et al., 2007) was used. In this technique, the child had to stand motionless with closed eyes in a certain position for 75 seconds, without being distracted by external sound stimuli (tapping, coughing, the sound of a pen falling on the floor, etc.). For each 5-second interval three types of mistakes were recorded (*i.e.*, movements, the opening of the eyes, vocalizations); the child received two points if she/he made no mistakes during the 5-second interval; one point if child made one type of mistake; and 0 points if child made two or more types of errors (max 30 points).

**For cognitive flexibility** assessment, the Dimensional Change Card Sort task (Zelazo, 2006) was used. The children were required to sort a series of cards with pictures of red rabbits and blue boats following different rules. In the first task, the child sorts six cards by color (red ones are put in one direction, blue ones in the other). In the second, six cards are sorted according to the shape (boats are put in one direction, hares in the other). In the third task a child has to arrange 12 cards based on the complex rule: if the card had a black frame, then he/she had to sort it by color, and if there was no frame, then he/she had to sort it by form. For each correctly placed card, a child received one point; at the end the total number of points was calculated (max 24 points).

**To study the characteristics of DD use by the children**, an online questionnaire was distributed among the mothers; it contained questions about socio-demographic factors (place of residence, age and gender of the child), and the family's socio-economic characteristics (income level, level of education of the mother). The mothers also had to estimate in minutes how much, on average, on a typical day the child spends watching video content, and how much the child play with the help of DD (separately for weekdays and weekends). Then the average weekly passive and active screen time of the children was calculated.

The following questions were asked regarding joint media engagement of children and family members:

1.   "With whom does the child usually watch cartoons, films, and videos on the Internet or on TV?" Parents were asked to choose one of the following options: "Alone," "With a brother or sister," "With adult family members," or "Other."

2.   "With whom does the child usually play on electronic devices?" Parents were asked to choose one of the following options: "Alone," "With a brother or sister," "With adult family members," or "Other."

In cases where parents chose the answer "Other," their answers were not further analyzed.

## Procedure

The study was carried out in two phases, one year apart. During the first phase, the EF of the children from senior kindergarten groups were evaluated. At the same time, their mothers filled out online questionnaires about the specifics of their children's use of DD. During the second phase, a year later, when the children were in the preparatory kindergarten groups, their EF were re-evaluated.

During both phases, EF assessment was carried out individually with each child, in a quiet room familiar to children (in their kindergarten). The evaluations were carried out over two meetings, each lasting approximately 20 minutes. During the first meeting, the children performed the tasks aimed at assessing their cognitive flexibility and inhibitory control; during the second one, the tasks aimed at assessing working memory. The sequence of tasks was fixed in both phases of the study and was the same. The tasks were split into two meetings in order to avoid overwhelming the children during the evaluation. Informed consent was obtained from parents for the participation of their children in the study.

During the first phase of the study, the children's mothers received a link to the questionnaire that they filled out via an email from municipal educational organizations or in a parent chat in the WhatsApp messenger. It took the mothers approximately 20 minutes to complete the online questionnaire.

## Results

### Descriptive statistics

According to the data obtained from the survey of the mothers (see *Table 1*), approximately half of the children watched cartoons, films, and videos with their siblings (53.7%), while a third of the sample watched them alone. Only 15.6% of the children watched content with their parents. In the case of active screen time (play on electronic devices) compared to passive screen time (video watching), a larger number of children played on their own (40.1%), while the percentage of those playing with siblings decreased slightly; those playing with their parents remained approximately the same. Therefore, not all the children who had siblings, usually used DD with them.

It is crucial to emphasize that many parents reported that their child did not play on a digital device at all. Therefore, the number of children about whom parents answered the question "with whom the child plays using DD" (n = 379) was much lower than the number of children about whom parents answered the question "with whom does the child watch video content" (n = 475).

**Table 1**

*Survey results of mothers about how long and with whom their child usually spends passive and active screen time*

|  | Passive screen time (n=475) | | Active screen time (n=379) | |
| --- | --- | --- | --- | --- |
|  | With whom does the child usually watch cartoons, films and videos on the Internet or on TV? | Average screen time per day (min) | With whom does the child usually play on electronic devices? | Average screen time per day (min) |
| Alone | 30.7% | 114 | 40.1% | 75 |
| With siblings | 53.7% | 105 | 45.9% | 85 |
| With parents | 15.6% | 98 | 14.0% | 45 |

According to the data obtained, the children showed improvement in most EF components over the year (see *Table 2*). At the same time, the EF level at both the first and second stage of the study corresponded to the previously obtained norms for these ages in a Russian sample (Veraksa et al., 2020a).

**Table 2**

*Descriptive statistics of EF evaluation results in preschool children ages 5 and 6 years*

|  | First phase (5-6 y.o.) | | Second phase (6-7 y.o.) | |
| --- | --- | --- | --- | --- |
|  | **Mean** | **Standard deviation** | **Mean** | **Standard deviation** |
| Cognitive Inhibition | 10.2 | 3.09 | 11.4 | 3.28 |
| Physical Inhibition | 25.0 | 5.03 | 27.1 | 4.49 |
| Cognitive Flexibility | 20.4 | 3.01 | 20.0 | 2.44 |
| Visual Working Memory | 74.2 | 17.8 | 92.1 | 19.8 |
| Verbal Working Memory | 17.0 | 3.83 | 19.5 | 4.33 |

Due to the fact that the distribution of changes in the development rate of EF components over the year (the difference between scores) was not normal (according to the Shapiro-Wilk test), the nonparametric Mann–Whitney U test was used for further analysis.

### EF development over a year and the joint media engagement of preschoolers and their parents

Since there were significantly fewer children who often watched video content with adults than children who often watched video content alone, sex- and age-matched children were randomly selected from the latter group so that the groups were equal in size. The groups were similarly equalized in terms of both passive and active screen time with siblings.

According to the data, the children who more often watched video content alone had a greater increase in cognitive flexibility skills over the year than those who more often watched video content with their parents (Mann-Whitney test U = 1842.500, p = .007). At the same time, the majority of children who watched content with their parents showed a decrease in the level of cognitive flexibility (see *Figure 1*). In addition, children who watched video content alone had statistically significant higher screen time that children who watched video content with their parents (Mann-Whitney test U = 4368.500, p = .029) (see *Table 1*).

There were no statistically significant differences in development of EF components between children who usually played alone on the DD and those who usually played with adults.
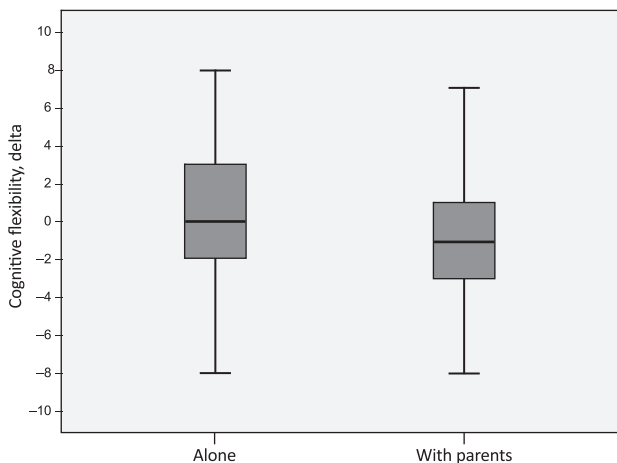
*Figure 1.* Differences in the cognitive flexibility development rate between children who watch video content alone and those who usually watch it with their parents

### EF development over a year and the joint media engagement of preschoolers and their siblings

We found that physical inhibition increased over the year significantly more in those children who watched video content with siblings, compared to those children who more often watched it alone (Mann-Whitney test U = 5341.000, p = .011) (see *Figure 2*). Those children who often played on DD with their siblings showed a significantly higher increase in their inhibition over the year compared to those who more often played alone (Mann-Whitney test U = 5277.500, p = .018) (see *Figure 3*). The Mann-Whitney test showed that there were no statistically significant differences in either the passive or active screen time of the children who used the DD alone and with siblings (see *Table 1*).
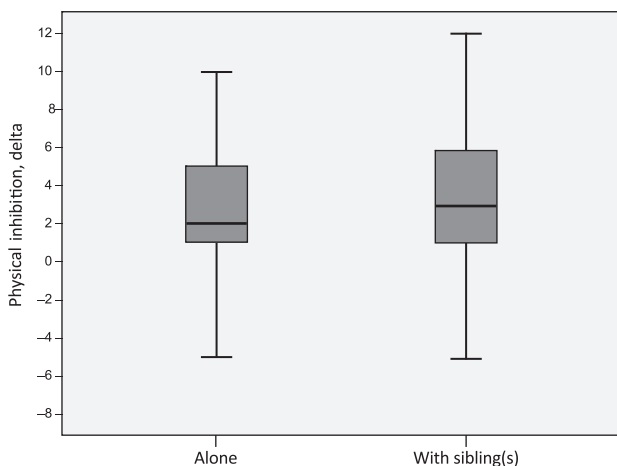


*Figure 2.* Differences in the physical inhibition development between children who watch video content alone and those children who watch it with siblings
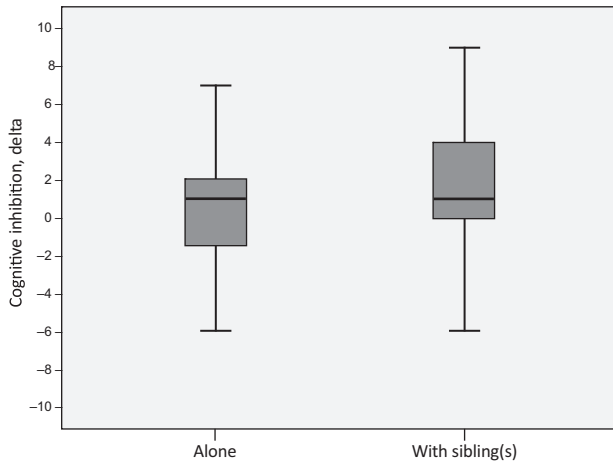
*Figure 3.* Differences in the cognitive inhibition development between children who play digital games alone and those who play with siblings

## Discussion

The purpose of this longitudinal research was to study the relationship between the development of the main components of EF in preschool children over a year (from 5–6 to 6–7 years old) and the characteristics of joint active and passive screen time. We formulated a research question about how the development of EF component over a year was related to the characteristics of the joint media engagement.

As a result, it was discovered that many children who watched video content with their parents showed a deterioration in cognitive flexibility over the year, in contrast to those children who watched video content alone. There are several explanations for this result. First, it can be assumed that independent viewing of video content by preschoolers involves the child's independent search and selection of cartoons or videos that interest him/her, which can contribute to his/her cognitive flexibility development. A child may use different strategies to find video content of interest. Also, when searching, the children have to pay attention to the different characteristics of video captions and splash images, which are important to consider in order to find what you are looking for. In the cases where children co-viewed video content with their parents, it can be assumed that the search and selection was carried out by the adult. Second, parents were also more likely to engage the types of media that they themselves used more often (Connell et al., 2015; Dore & Zimmermann, 2020). It can be assumed that in this case, the child's cognitive flexibility might develop less actively, since the child was forced to follow the type of digital activity chosen by the adult and did not have sufficient experience in changing digital contexts to contribute to the cognitive flexibility development. Third, some parents, due to not having much digital competence, offered their child a small range of apps and video content, and did not know how to find appropriate educational content.

Finally, another reason may be that the joint media engagement was often "low-level" (Dore & Zimmermann, 2020), meaning that in the process, parents paid insuf-

ficient attention to discussing what they saw with the child and were not emotionally involved enough in this process (Ewin et al., 2020). In these cases, passive video content co-viewing did not become a source of live communication between a child and an adult, which could have strengthened child-parent relationships and contributed to EF development. It can be assumed that if a parent would ask the child questions about what he/she saw after co-viewing video content, — for example, about how the child understood what happened, about the reasons for the behavior of the characters and the consequences of their actions, about the child's own thoughts and feelings — then this would contribute to both working memory training, as well as cognitive flexibility and other cognitive functions (Bukhalenkova et al., 2021; Ewin et al., 2020).

The screen time of those who usually watched video content on their own was higher than the screen time of those who usually watched with their parents. This result is inconsistent with existing evidence that more screen time is associated with lower rates of cognitive flexibility development (Bukhalenkova et al., 2021). It can be assumed that the difference of 16 minutes per day (114 minutes per day for those who watch alone, 98 minutes for those who watch with their parents) was not significant, and the features of sharing the control center played a larger role. However, it is possible that, unlike co-viewing time, the child's independent viewing time of video content was not accurately known to parents, and they slightly overestimated it. However, in any case, this result needs to be rechecked and clarified.

At the same time, no significant differences were found in the development of all EF components between children who usually played with DD independently and children who usually played with their parents. The lack of differences may be due to the fact that most video games and mobile applications are designed to involve only one person (Dore & Zimmermann, 2020), so in such cases, joint media engagement often does not include full interaction between the child and the partner, but rather observation of the partner's activities. Such a situation will be more likely to be typical for interaction with an adult, who can be either the main player (when a child watches one of the parents play) or, conversely, only a passive observer of the child's play. In the case of senior preschoolers, the situation where an adult only watches his/her child play is almost the equivalent of the situation of a solitary game; this may explain the lack of differences.

When playing video games together, children often act as two equal players. First, it is more interesting for them to compete with each other, and second, the two children both want to play on the DD and are often not ready to give in to each other, so they have to agree on the conditions of playing together, often changing roles (*e.g.*, they have to agree who is watching the game, and who is playing) (McAlister & Peterson, 2013; Rolan et al., 2018). In this regard, the differences we found in the inhibitory control development when the children were playing together with peers seem logical and natural. It was found that children who played video games and watched video content with siblings developed greater inhibitory control development over the course of a year than children who did so alone.

Interestingly, DD use with siblings to view video content (passive screen time) was associated with physical inhibitory control, which may be explained by the need to sit quietly and not interfere. On the other hand, DD use with siblings for games (active screen time) turned out to be associated with cognitive inhibitory control —

that is, the ability to restrain impulsive reactions in the case of performing cognitive tasks. The situation of interaction with a sibling while playing undoubtedly contributes to cognitive inhibitory control training: an older sibling can teach a child new skills to cope with his/her behavior during play (Vygotsky, 1978), and a play situation with a younger sibling will contribute to training patience in a preschooler. In addition, in a situation of joint play with a younger sibling, the child can act as a teacher, which will also contribute to his/her self-regulation development, since he/she will need to take care not only of himself/herself, but also control the younger sibling.

Let us note that no statistically significant differences were found in either the passive or active screen time between children who used DD alone and with siblings, which allows us to conclude that the screen time factor did not influence the results obtained on the relationship between the EF development over the year and joint media engagement with siblings. Therefore, the data obtained allow us to conclude that at preschool age, joint media engagement with siblings has the most significant effect on inhibition development.

No significant differences were found in working memory and cognitive flexibility between children who usually used DD alone and those who used it with their siblings. To explain the absence of differences, further research on the nature of joint media engagement with siblings (how exactly the children interacted) is needed.

## Limitations

There were a number of significant limitations of this study. Let's start with those associated with collecting information from the parents about the joint media engagement. First, in the questionnaire, parents could choose only one option, which limited their ability to reflect reality. For example, there could be children who used DD with approximately equal frequency on their own and with someone else. But the parents of such children were forced to choose only one answer. When using this questionnaire in the future, it is planned to make it possible to select several answers and indicate the frequency with which each option is practiced in the family. Second, parents, due to social desirability or limited awareness, may have given inaccurate answers to the questionnaire. For a more complete and objective picture, researchers can also interview the children themselves in the future. A third limitation was the lack of detail in the questions. For a deeper understanding of the topic of joint media engagement, it would be important to add more clarifying questions to the questionnaire about how exactly the joint media engagement occurred: *e.g.*, how the participants agreed among themselves, whether they discussed what they saw, or the experience gained. It also seems relevant to consider screen time. In addition, the age of the siblings was unknown, which is also a significant limitation of this work.

The next limitation of the study was that the survey on DD use was carried out only during the first phase. That is, the study was based on the assumption that the method of DD use did not change significantly over the year, while, in reality, the features of joint media engagement could have changed dramatically over the course of the year. For example, the family's living conditions or the composition of the family could have changed. In the future, when conducting longitudinal studies, it is neces-

sary to run a repeat survey at the final stage. Another limitation was the fact that the mere presence of a sibling may be associated with higher levels of EF (McAlister & Peterson, 2013; Rolan et al., 2018). So, the finding that joint media engagement with siblings is associated with higher level of inhibition development may actually be explained simply by having a sibling and interacting with him or her.

Another significant limitation of the work was the differences in screen time between children who watched video content on their own and those children who watched video content with their parents. In the future, it is necessary to compare the features of shared use of DD between groups of children with equal screen time.

Also, this research did not take into account many other factors that could affect EF development, such as the quantity and quality of the children's sleep (Kahn et al., 2021) and their physical activity (Bai et al., 2020), the children's attendance at various additional classes (Dolgikh et al., 2023), and features of the parent-child relationships (Valcan et al., 2018) and others. It is important to take these parameters into account in future research. It is also necessary for future research to consider parents' education level, family income, and parental attitudes toward DD, as these features may influence how parents use DD with their children (Aleksandraki & Zaranis, 2023; Papadakis et al., 2022; Waters et al., 2016).

## Conclusion

The data obtained in this study complements and expands our knowledge about the impact of joint media engagement on EF development at preschool age. It has been demonstrated that 5- to 6-year-old children who played video games and watched video content with siblings experienced more intensive inhibitory control development over the year than those children who did it alone. At the same time, the children who watched video content with their parents showed a deterioration in cognitive flexibility over the year, unlike those children who watched such content alone.

This research shows the importance of organizing joint leisure time with a child using DD, especially if the child uses them alone all the time. Based on the results obtained and analysis of the limitations of this study, suggestions for future research can be formulated. Thus, the survey questions about DD use should be made more precise and detailed in order to have more information. At the same time, in addition to the questionnaire for parents, it is worth using other sources of information (surveying the children themselves).

## Ethics Statement

The study was reviewed and approved by the Ethics Committee of Faculty of Psychology at Lomonosov Moscow State University (approval no: 2022/15).

## Informed Consent from the Participants' Legal Guardians (if the participants were minors)

Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## Author Contributions

D.B. and E.C. conceived of the idea. D.B. and E.C. developed the theory and performed the computations. E.C. and A.O. verified the analytical methods. All authors discussed the results and contributed to the final manuscript.

## Conflict of Interest

The authors declare no conflict of interest.

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