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How schoolchildren use digital media in class and outside of school over several weeks: a quantitative case study with media diaries

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Introduction: Digital media play a central role in the lives of today's schoolchildren, immersed in an increasingly digital world. Modern technologies blur the lines between formal school settings and informal settings outside of school. Although formats like bring-your-own-device align the use in the formal setting with informal usage, a disjunction exists between children's interactions with digital technologies in their home environments and those within the educational setting. For bridging the gap between school learning and children's lives outside of school, it is essential to explore the differences and similarities in media usage in both settings.

Methods: In our case study, we examined schoolchildren's motives and evaluations of digital media usage in both settings, addressing individual needs. Additionally, we explored several dimensions of digital literacy through self-assessment, identified associated learning opportunities within and outside the school environment, and captured self-reported learning gains. We collected this data over the course of several weeks in a longitudinal design with media diaries, aiming to estimate the extent of the fluctuation.

Results: Eighty-four German schoolchildren aged between 10 and 16 years participated over a six-week period. We found differences but also similarities between media usage outside of school and in class. Digital media were less frequently used in class for entertainment, communication, and learning compared to outside of school, but no differences were reported regarding information search. Schoolchildren expressed above-average satisfaction with their media usage in both settings, but they perceived the usage of digital media outside of school as significantly more important than in class. Regarding their digital competencies, the schoolchildren displayed high self-confidence in most areas. Only in the areas of algorithms and programming, schoolchildren rated themselves as below average. While learning opportunities were identified in class and outside of school, the frequency of these opportunities varied across different digital skills. The self-reported learning gain in digital media usage remained consistently low in both settings. Across all analyses, there was no substantial temporal fluctuation in media usage over the study period.

Discussion: The findings raise crucial considerations regarding the integration of digital media in the classroom, fostering a discussion on their implications for both research and educational practices.

KEYWORDS

informal and formal media usage, individual needs, digital literacy, learning opportunities, media diary

1 Introduction

In the contemporary landscape, schoolchildren are deeply immersed in digital media from an early age. As each new generation grows up surrounded by smartphones, laptops, tablets, and internet-enabled game consoles, these technologies have become indispensable in their lives. In Germany, 94% of 12-to 19-year-olds own a smartphone, and 88% use the internet daily (MPFS, 2021). Additionally, children are being exposed to digital media at an increasingly early age. While in 1970 children watched television for the first time at the average age of four, today children are only about four months old when they use digital media for the first time (Reid-Chassiakos et al., 2016). Termed the "Digital Youth" (Ito et al., 2010), this generation is the first to grow up without experiencing a world devoid of the internet, virtual reality, and smart technologies (Williams, 2015). Their ability to seamlessly integrate modern technologies into all aspects of their lives is evident, highlighting a natural fluency that is shaping their identity (Ziatdinov and Cilliers, 2021).

Moreover, the invention of wearable digital media and the internet blurs the boundaries between formal and informal settings (Cox, 2012). Two decades ago, the idea that schoolchildren could use their own personal devices in school seemed unthinkable. However, today, the concept of bring-your-own-device has become an integral part of many schools worldwide (Parsons and Adhikari, 2016). Conversely, schoolchildren frequently utilize digital media during their leisure time to gather several types of information, including subjects traditionally taught in school, for example political information via YouTube (Zimmermann et al., 2020). They can contact friends and family at school and easily discuss homework with classmates at any time after school. Hence, with the progress of technology, similar media behaviors can now be experienced across different settings, effectively blurring the once clearly defined boundaries of media usage.

Nevertheless, establishing a connection between the informal literacy practices that children develop at home and the formal ones cultivated in the school environment presents inherent challenges, as discussed by Burnett (2010) and McTavish (2010). "Third space pedagogy" underscores the importance of bridging the learning spaces between the capabilities developed in informal settings and classroom activities. This task is acknowledged as both a challenging aspect and a crucial objective in the field of education, as highlighted by Edwards-Groves (2011). Undheim (2022) describes "disconnected contexts" as instances where a noticeable gap or disjunction exists between children's interactions with digital technologies in their home environments and those within the educational setting. This observation aligns with findings from a cross-sectional study conducted by Wang et al. (2014). They compared schoolchildren's digital media usage inside and outside of school and found a discrepancy between these settings. They argued that media integration in schools may be hindered by insufficient teacher training (Wang et al., 2014). Acknowledging children's experiences at home would require teachers' readiness, as well as the awareness of the "digital difference" between these experiences at home and those expected in formal settings.

Understanding the differences and similarities in children's digital media usage inside and outside of school is crucial. Even if differences in media use, especially in the entertainment sector, can be easily observed in one's own environment, empirical studies are necessary in order to systematize and validate these occasional observations and to identify opportunities for linking formal and informal learning. In this sense, educational practitioners have advocated for bridging the gap between school learning and children's lives outside of school to enhance their intellectual growth and development (Banks et al., 2007; Kumpulainen et al., 2010). By examining comparative studies, recommendations for teacher education can be formulated to further integrate school teaching with lifelong learning (Wang et al., 2014). Following this objective, the present study focused on the following two domains:

First, we focused on the individual needs of schoolchildren by investigating their motives for using digital media both in class and outside of school, as well as their evaluations of their digital media usage in both settings.

Second, we explored various dimensions of digital literacy. For this purpose, we surveyed the schoolchildren, seeking their self-assessment regarding their digital literacy. Additionally, we explored the availability of learning opportunities both within and outside school for the development of these skills, alongside assessing their self-reported learning gains. These analyses allowed us to pinpoint the specific areas of competence where schoolchildren expressed confidence and the settings in which they perceived learning opportunities.

Furthermore, our study integrated a unique aspect by investigating digital media usage over several weeks. By employing a longitudinal design, we were able to gather information about temporal fluctuations in media usage. Previous literature focused primarily on examining the average daily or weekly media usage, which oversimplifies the analysis by calculating multiple days or weeks into a single average value and overlooks the important structural dimensions of time (Ren et al., 2013). It remains unclear whether and to what extent digital media usage behavior fluctuates across weeks. Therefore, to gain a better understanding of digital media behavior, it is essential to capture temporal aspects beyond averaged usage durations. Considering this, we compared both settings not only in terms of settings but also in terms of temporal patterns using a modified form of media diaries.

Given the exploratory nature of this approach and the thin empirical basis so far, we considered a case study to be particularly suitable. A case study is defined as an intensive investigation of a single unit to understand a larger class of similar units. The unit being studied is spatially and temporally bounded and provides detailed insights that can be applied to broader contexts (Gerring, 2004). In view of the objectives at hand, a school represents such a unit, which can serve as a representative example for other schools or educational institutions. For this reason, we selected one school as a case for the present study in order to carry out a detailed analysis of specific patterns and practices of media use in formal and informal settings.

1.1 Individual needs

1.1.1 Motives of digital media usage

There are various reasons to use digital media inside and outside of school. The uses-and-gratification approach (U&G, Katz and Foulkes, 1962) is one framework that seeks to explain why and when people use (digital) media. It suggests that individuals strategically use

digital media to fulfill their personal needs, selecting media based on how well they satisfy those needs. While U&G is not a homogeneous theory (Rubin, 2009), different models propose that individuals have multiple social and psychological needs that generate specific expectations about how digital media can fulfill those needs. Research showed that people use digital media for information (e.g., Kaspar and Müller-Jensen, 2021; Ku et al., 2013; Malik et al., 2016) entertainment (e.g., Ku et al., 2013; Krause et al., 2014), learning (e.g., Aladwani, 2014; Korhan and Ersoy, 2016) and social interaction and integration (e.g., Meier et al., 2021; McQuail, 1994; Ancu, 2012; Giannakos et al., 2013). Communication, in general, appears to be the primary motive for teens to use digital and social media (Tanta et al., 2014), among other motives (cf. Heravi et al., 2018). The U&G approach underscores the active role of individual users in selecting and consuming digital media to satisfy their needs (Katz et al., 1973).

However, the assumed active role in the selection process for need gratification may differ significantly when comparing in-class usage to usage outside of school. In the school setting, teachers typically dictate when and how digital media should be used. In contrast, outside of school, schoolchildren have more freedom to fulfill their needs with media as they wish. This difference was also observed in the study by Lu et al. (2016), which found that students used social media more actively and diversely outside of school than inside school. Information sharing and creation were more prevalent in the school setting, whereas information consumption occurred more frequently outside of school. Similarly, Clark et al. (2009) found that teenagers engage more extensively with social media outside of school than within it. However, Lu et al. (2016) also revealed similarities between these settings. They showed that schoolchildren in both settings consume, share, and create content on social media. Other studies either focused only on leisure time when identifying individual needs or did not explicitly separate it from school-related usage (e.g., Alhabash and Ma, 2017; Sheldon and Newman, 2019). To comprehend why the two settings are "disconnected" (Undheim, 2022), we examined the individual needs of schoolchildren in both settings.

Although usage motives appear stable over time, the U&G does not clearly delineate how social factors interact with environmental factors to affect digital media usage. In contrast to personality traits, which tend to remain relatively stable over time, individual needs are subject to change, thereby impacting the motives behind digital media usage (Anderson, 2011). Additionally, certain needs, such as studying for an upcoming exam, may become more important than others at specific times, thereby influencing motives and potentially leading to temporal fluctuations. A representative German study (MPFS, 2018) showed that 35% of teens' digital media usage time was spent on communication, 31% on entertainment, 24% on games and 10% on information search. The findings were consistent with previous studies from MPFS (2016, 2017) and suggest that usage motives remained relatively stable over the years despite the further development of digital media. This is in line with findings from numerous studies (e.g., Papacharissi and Mendelson, 2011; Sheldon, 2008; Smock et al., 2011) which showed that motives of digital media usage did not change in recent years. However, little is known about whether there are individual fluctuations in the importance of usage needs on a smaller temporal scale. To the best of our knowledge, no study measured usage motives of schoolchildren over several weeks. Therefore, it is unclear if and to what extent motives of digital media usage fluctuate over time and what role the (formal or informal) setting plays. In order to address this research gap and gain insights into the motives of digital media usage both inside and outside of school, we formulated the following research question:

> *RQ1a*: What are the motives behind digital media usage of schoolchildren in class and outside of school, are there differences between and within formal and informal settings, and how do these motives fluctuate over a period of several weeks?

1.1.2 Evaluation of digital media usage

Our study delves into the evaluation of satisfaction and importance regarding the persistent use of digital media by schoolchildren in both settings. According to the U&G approach, the persistent usage of a media is contingent upon it fulfilling the expected gratification initially sought (Palmgreen and Rayburn, 1982). It states the importance of aligning individuals' motivational concerns with situations that can satisfy those concerns over extended periods of time. It distinguishes between the gratifications sought and the gratifications obtained (Rayburn and Palmgreen, 1984), noting that these may not always correspond to each other. Only when (digital) media usage fulfills the expected gratification should it be likely that individuals will continue to use it to satisfy the same needs (Palmgreen, 1984), even if this theoretical assumption may not always apply in practice (e.g., in the case of forms of media addiction). From a U&G perspective, satisfaction with digital media usage is considered an outcome of behavior (Luo et al., 2006). The U&G approach emphasizes consumer awareness of needs, highlighting the increasing importance of digital media with effective gratification. This comprehensive assessment of satisfaction and importance ratings contributes to a deeper understanding of the nuanced needs and preferences of schoolchildren in both formal and informal setting. Thus, we investigated following question:

> *RQ1b*: How satisfied are schoolchildren with their digital media usage in class and outside of school, how do they rate the importance of media usage in both settings, and how do these satisfaction and importance ratings fluctuate over a period of several weeks?

1.2 Perceived digital literacy

Digital media usage not only has positive aspects but also carries risks that can lead to negative consequences without sufficient digital literacy. Many teens engage in careless and thoughtless usage of digital media, such as disclosing personal information or becoming highly distracted (Knop et al., 2015). Additionally, 77% of young users in Europe claim to encounter fake news at least once a week (European Commission, 2023). The prevalence of cyberbullying is another concerning issue among schoolchildren due to increased social media usage (Alim, 2017). As the "Digital youth" is becoming younger, experts emphasize the importance of promoting responsible digital media usage from an early age (Bachmann et al., 2021). Therefore, it is crucial for schoolchildren to actively cultivate and enhance their digital literacy skills to navigate the complexities and potential risks associated with digital media usage.

Digital literacy is a construct that lacks a clear definition in research and practice, as it constantly evolves and adapts to modern technologies.

The Council of the European Union has recognized digital literacy as one of the eight key competences "essential to citizens for personal fulfillment, a healthy and sustainable lifestyle, employability, active citizenship and social inclusion" (European Commission, 2019, p. 4). According to the European Commission (2019), digital literacy involves the confident, critical, and responsible usage of digital technologies, as well as their skillful application in learning, working, and societal participation. Schools play a vital role in fostering these competences, as they reach all school-age children during their educational journey (Paakkari et al., 2019; Videto and Dake, 2019), including digital literacy (König et al., 2022). In recent years, significant efforts have been made at the international and national levels to develop frameworks, self-assessment tools, and training programs to enhance digital literacy (Redecker, 2017). In Germany, each federal state has implemented its own initiatives to integrate digital media education into the curriculum. An example of such an implementation is the *Media Competence Framework of NRW* (Medienberatung NRW, 2020). It defines six different areas in which schoolchildren should systematically acquire key digital literacy skills (see Table 1). Each of these six competence areas is further subdivided into four competence facets. The framework aims to enable teaching of digital literacy, basic education in information technology, and subject-related learning with digital media across all school levels. The *Media Competence Framework of NRW* serves as the foundation for developing school-specific media concepts in the German federal state of North Rhine-Westphalia. All schools in this region, with a population of 17.9 million, are mandated to formulate a media concept tailored to their pedagogical requirements and available resources. This concept must be based on the school program and include a school-specific qualification concept (BASS, 2019). Schools were mandated to implement their media concepts starting in the summer of 2019. However, 6 months later, the Covid-19 pandemic emerged, making it unclear to what extent the media concepts have been integrated into everyday school life during the period when the present study was conducted. In the absence of a validated test instrument specifically aligned with the NRW Media Competence Framework for schoolchildren during the study, we opted to investigate the facets through a self-report questionnaire. Self-reports offer valuable insights into the subjective perceptions of schoolchildren, shedding light on areas where they seek support. This not only informs us about their individual experiences but also allows us to derive pedagogical interventions based on their subjective perspectives. The U&G approach underscores the significance of emphasizing these subjective viewpoints in guiding our educational strategies. For this purpose, we asked:

TABLE 1 The six competence areas of digital literacy defined by the *Media Competence Framework of NRW*.

	Competence area	Definition
1	Handle and apply	Ability to use digital media wisely
2	Inform and search	Ability to assess the accuracy of information
3	Communicate and cooperate	Ability to master the rules for secure communication
4	Produce and present	Ability to creatively design digital media products
5	Analyse and reflect	Ability to critically deal with digital media offerings
6	Problem solving and modeling	Ability to solve technical problems

> *RQ2a*: How do schoolchildren perceive their own level of digital literacy?

1.3 Perceived learning opportunities for acquiring digital literacy

However, schoolchildren acquire digital literacy not only within the confines of the school but also beyond it, aligning with the concept of lifelong learning (cf. Aspin and Chapman, 2000). Parents play a significant role in influencing their children's usage of media and their digital literacy by teaching critical internet use skills and setting technical limitations, which is associated with higher internet use skills among teenagers (Garmendia et al., 2012; Livingstone et al., 2017). Riesmeyer et al. (2019) found a positive relationship between warmth of parenting and the child's ability to criticize media. Additionally, the behaviors of siblings, classmates, and friends influence the digital media usage habits of schoolchildren (Terras and Ramsay, 2016). Furthermore, many leisure activities, such as visiting museums, zoos, or libraries, often utilize digital media to deliver targeted knowledge to teenagers (Hsi et al., 2005). Hence, learning opportunities for acquiring digital literacy extend beyond the school environment and are present in the everyday lives of schoolchildren.

The provision of learning opportunities relevant to the content is considered a crucial factor in influencing learning outcomes (Osterberg et al., 2018). This idea stems from Piaget's Theory of Constructivism (cf. Amineh and Asl, 2015), which posits that new knowledge is constructed through active engagement with the learning object, in this case, digital media. Learning is viewed as an active process of knowledge construction rather than passive information storage. Learning opportunities empower schoolchildren to independently engage with learning content, enabling them to discover connections on their own. The positive effects of learning opportunities on competence development were often demonstrated in teacher education (e.g., Blömeke et al., 2012; Tachtsoglou and König, 2017; Stancel-Piatak et al., 2013; Schmidt et al., 2011). Moreover, similar positive effects were also found among children. Marcus et al. (2021) showed that learning opportunities fostered children's engagement with technical practices in informal settings, particularly in testing and redesigning. Combining learning opportunities with experiments and discussions about everyday scientific situations resulted in significant improvements in children's scientific understanding (Marcus et al., 2021). Hence, learning opportunities can have positive effects on competence development across different age groups.

Formal learning opportunities differ from informal learning opportunities. Formal learning opportunities occur within institutions that provide structured teaching-learning settings and lead to formal qualifications (Osterberg et al., 2018). In contrast, informal learning opportunities are often situational, spontaneous and may not be perceived as formal learning processes (Osterberg et al., 2018). Specifications for formal learning opportunities exist, such as those outlined in the *Media Competence Framework of NRW*, which provides schools with examples of the necessary content of media-related learning opportunities. Thus, schools are obliged to develop and integrate such learning opportunities into formal settings. However, learning opportunities in informal settings are not predetermined. Therefore, we explored the following research question:

> *RQ2b*: Which learning opportunities for acquiring digital literacy do schoolchildren consciously perceive in class and outside of school over a period of several weeks?

1.4 Perceived learning gains

While learning opportunities have shown positive correlations with competence development, they do not indicate the extent to which children have acquired knowledge and skills related to digital media. However, assessing this learning outcome is crucial for evaluating the relevance of different settings in relation to competence development. Traditionally, learning outcomes are assessed at the end of the school year using performance tests. Since such tests are not yet available for the broad range of media literacy of schoolchildren, perceived learning gains in using digital media can serve as a suitable proxy. Older studies have found that perceived learning gains appeared to be valid measures (Anaya, 1999; Pike, 2011). Furthermore, perceived competence gains reported by students have shown a positive relationship with observed learning opportunities (Braun and Hannover, 2011). These findings underscore the importance of subjective perceptions in assessing learning effectiveness. To further examine whether learning gains fluctuate or differ between the two settings, our final research question is as follows:

> *RQ2c*: How do the schoolchildren rate their perceived learning gain in using digital media in class and outside of school over a period of several weeks?

2 Materials and methods

To address all research questions, we implemented a media diary study over several weeks accompanied by an initial survey. This allows us to examine similarities and differences between media usage in formal and informal settings and to observe how digital media usage fluctuates over the period of several weeks.

The data in this study are derived from a large-scale German research project that investigated media education processes in lower secondary schools. As part of this project, we examined the digital media usage of schoolchildren in formal, non-formal, and informal settings. Due to the Covid-19 pandemic, non-formal education was significantly impacted and often excluded, thus it was not included in our analyses. A total of 200 children from eight schools participated in the media diary studies. After completing an initial survey, the schoolchildren were divided into two groups for the media diary study, which took place on a weekly basis. One group participated in the quantitative study, while the other group took part in a qualitative study. Prior to implementation, the study received ethical approval from the ethics committee of the faculty of human sciences at the University of Cologne (KKHF0106). This research paper focuses on the data obtained from the *quantitative* media diaries.

2.1 Participants

The study involved two types of surveys: an initial survey, which was completed once at the beginning, and media diaries filled out by the schoolchildren a total of four times. We created all surveys using the Unipark software (Tivian XI GmbH). At each measurement time, the schoolchildren were required to provide a personal four-digit code to ensure data matching. They were then informed about their rights and asked to give their consent to participate. From the initial survey participants, a total of 128 schoolchildren were assigned to the quantitative media diary study. The dropout rate in the media diary part was relatively high: 30 of the 128 schoolchildren did not participate in the media diary at all, 23 participated only once, 17 participated only twice, and 10 participated three times. A total of $n = 48$ (28 female, 20 male) schoolchildren completed all four weekly measurements of the media diaries. Given the vital importance of temporal analyses in this study, our analyses focused on these 48 complete data sets based on four media diaries. The schoolchildren ranged in age from 10 to 16 years ($M = 11.67$, $SD = 1.46$) and were in 5th to 10th grade (5th grade $n = 13$, 6th grade $n = 16$, 7th grade $n = 7$, 8th grade $n = 5$, 9th grade $n = 6$, 10th grade $n = 1$).

All children came from the same school in order to maintain identical organizational and infrastructural boundary conditions for all participating children. We specifically chose a full-day school that had an average level of media equipment compared to other schools in Germany, making it a prototypical example for our case study. By focusing on a single, well-defined school environment, we were able to control for external variables and maintain consistency in the experiences and events affecting the schoolchildren, which is crucial for the integrity and validity of a case study (Gerring, 2004). Different schools often have varying schedules and informal thematic focuses, which could introduce inconsistencies. By selecting a single school, we ensured that events within the school were the same for all participants of this study. Moreover, the coherence of the technical infrastructure, the governance by the school administration, and the school culture is essential for the collection of reliable data.

2.2 Procedure

Initially, the school obtained approval from the school committee to allow schoolchildren participation in the study and informed all schoolchildren about the opportunity to take part. Registration for the study was solely carried out by parents, who provided online consent for their underage child to participate. Parents were informed that participation was voluntary and without any incentives, and that their child would not experience any disadvantages if they chose not to participate. They were also assured that participation could be stopped at any time and that data protection guidelines would be strictly followed. If parents agreed, they provided either their own email address or their child's address to facilitate weekly contact. On October 15, 2021, we sent the link to the initial survey, along with a personal code, to the provided contact address. The survey remained open for 27 days.

After the completion of the initial survey, we initiated the distribution of the quantitative media diary. Over a period of six-week, we sent an access link every Friday at noon. The schoolchildren were given until Sunday evening of each week to participate. They were instructed to complete the media diary a total of four times, after which they were not invited to participate further. However, during the six-week period, the schoolchildren were allowed to miss measurement time points without being considered as dropped out from the study. Consequently, participation in the study was measured at various times over the six weeks (see Supplementary material). The

first measurement started on November 5, 2021, and the final weekend measurement was on December 19, 2021. Each of the media diary surveys had an identical structure and always referred to the previous school week.

We deliberately chose the period between the autumn holidays and the Christmas holidays for our study because it is a time without major holidays and outside of acute exam phases, allowing it to serve as a baseline period of media usage. This period was selected to avoid any significant special events (e.g., sports world championships) that might skew the data. With approximately 1 month for the initial survey and 6 weeks for the media diaries, our study adheres to the longitudinal research standards outlined by Ployhart and Vandenberg (2010), which emphasize the observation of change and require a minimum of three repeated observations of a variable. To meet these criteria, we set a minimum participation requirement of four measurements.

2.3 Measures

2.3.1 Initial survey

In the initial survey, we collected relevant demographic information from the schoolchildren, including their age, gender, school affiliation, grade level, and whether they were involved in any specific non-formal activities at school. Additionally, we assessed their perceived digital literacy. Other variables that were collected for the large research project are not included in this study. To measure perceived digital literacy, we developed a scale consisting of 24 items, systematically derived from the theoretical framework provided by the *Media Competence Framework of NRW*. This framework, which is very similar in content to national (KMK, 2016) and international (DigComp 2.1; Carretero et al., 2017) models, is designed to enhance media literacy among schoolchildren and includes six competence areas: *handle & apply, inform & search, communicate & cooperate, produce & present and analyse & reflect*. Each competence area is further divided into four specific competence facets, resulting in a total of 24 facets that outline the media skills students should acquire (Medienberatung NRW, 2020). For each of these 24 facets, we created a single item to measure that specific competence. We had previously developed this format for the target group of (prospective) teachers and have now transferred it to children (cf. Jäger-Biela et al., 2020; König et al., 2022). Two independent researchers created the items, which were later discussed together. The items underwent content validity and comprehensibility checks by further media research specialists within the project team. Subsequently, the questionnaire was pre-tested with three schoolchildren from the target population and revised based on their feedback. The schoolchildren had to indicate how well they can do the listed media competencies on a 5-point scale without numerical markers ("I cannot do well at all," "I can do less well," "I can do moderately," "I can do quite well," "I can do very well") with an alternative option ("I do not understand that question/I have never done that before").

2.3.2 Weekly media diary

The media diary studies maintained a consistent design throughout all four measurement time points, centering on the preceding school week and examining digital media usage and learning opportunities.

First, we examined the schoolchildren's motives of digital media usage for need gratification purposes. Specifically, we inquired about the frequency of digital media usage for *entertainment* ("How often did you use digital media this week for entertainment (= fun)?"), *communication* ("How often did you use digital media this week for communication?"), *information search* ("How often did you use digital media this week for information search?") and *learning* ("How often did you use digital media this week for learning?"). Each motive was assessed independently, with schoolchildren providing separate responses for in-class (formal) and outside-of-school (informal) settings. They used a 5-point rating scale ranging from 0 ("never") to 4 ("very often"). The selection of the first three motives was based on findings from the representative German youth survey JIM (MPFS, 2018). We added the motive *learning* in response to the increased importance of digital media for learning during the Covid-19 pandemic (Naqvi and Sahu, 2020).

Second, we assessed the schoolchildren's evaluations of their digital media usage during the last school week. This included their level of satisfaction with their digital media usage ("How satisfied were you with the use of digital media this week?") and the perceived importance of digital media ("How important was the use of digital media for you this week?"). Each item was measured separately for in class and outside of school, using a 5-point rating scale ranging from 0 ("not satisfied at all" or "not important at all") to 4 ("very satisfied" or "very important").

Third, we measured the perceived learning gain ("How much did you learn about dealing with digital media this week?") separately for in class and outside of school ranging from 0 ("nothing at all") to 4 ("very much").

Finally, we measured the learning opportunities available for acquiring digital literacy. To measure this, we made slight adaptations to the perceived digital literacy questionnaire used in the initial survey. The items were reformulated to assess the frequency with which the schoolchildren applied the described competencies during the last school week. The 24 items were rated on a 5-point scale ranging from 0 ("never") to 4 ("very often") with an alternative option ("I do not understand that question"). After each learning opportunity, the schoolchildren were asked to indicate where the activity took place, with the options "in class" and "outside of school." If a schoolchild indicated that they had not engaged in an activity during the last school week but had marked a place for it, we subsequently corrected this by removing the place.

3 Results

3.1 Motives of digital media usage (RQ1a)

All analyses were conducted using SPSS 28. We calculated a 4 (time) × 2 (setting) × 4 (motive of digital media usage) ANOVA with time (first vs. second vs. third vs. fourth measurement time), setting (in class vs. outside of school), and motive of digital media usage (entertainment vs. communication vs. search for information vs. learning) as within-subject factors. The frequency of media usage for need gratification purposes served as dependent variable. The ANOVAs did not show any effects of time. There was no main effect of time, $F(3, 141) = 0.63$, $p = 0.600$, nor any interaction including time, all Fs ≤ 1.28, ps ≥ 0.248, $\eta_p^2 \leq 0.026$. However, we found a main effect

of setting, $F(1, 47) = 54.48$, $p < 0.001$, $\eta_p^2 = 0.537$, indicating that the schoolchildren used digital media more frequently outside of school than in class for need gratification. We also found a main effect of motives for digital media usage, $F(3, 141) = 14.95$, $p < 0.001$, $\eta_p^2 = 0.241$. Furthermore, and more importantly, the interaction between usage setting and motive of digital media usage was significant, $F(3, 141) = 60.49$, $p < 0.001$, $\eta_p^2 = 0.563$, whereas all other interactions with these factors were not (all $Fs \leq 1.28$, $ps \geq 0.248$, $\eta_p^2 \leq 0.026$).

For a more fine-grained analysis of this interaction, we compared the motives of digital media usage within each usage setting. Therefore, we calculated for both settings a separate ANOVA with motives of usage as within-subject factor, followed by Bonferroni-adjusted pairwise comparisons. In these analyses, we excluded time as a factor, because it did not show any effect in the previous analysis. Instead, we calculated a mean value for each participant per motive and setting over the four measurement time points. In class, there was a significant main effect of motives, $F(3, 141) = 59.75$, $p < 0.001$, $\eta_p^2 = 0.560$. Pairwise comparisons showed that all usage motives significantly differed from each other (all $ps \leq 0.013$). The motive of learning ($M = 2.93$, $SD = 0.91$) was reported most frequently by the schoolchildren, followed by information search ($M = 1.96$, $SD = 0.87$), communication ($M = 1.46$, $SD = 0.91$), and entertainment ($M = 0.99$, $SD = 0.89$) (see Figure 1). Outside of school, we also found a significant main effect of motives, $F(3, 141) = 14.25$, $p < 0.001$, $\eta_p^2 = 0.233$. Here, the pairwise comparisons indicated that digital media were used equally often for entertainment ($M = 3.00$, $SD = 1.02$), communication ($M = 2.86$, $SD = 1.00$), and learning ($M = 2.42$, $SD = 0.99$), whereas searching for information ($M = 2.04$, $SD = 1.04$) occurred significantly less often compared to other three motives (all $ps \leq 0.007$).

Furthermore, we compared the setting (in class vs. outside of school) for each motive. While the main effect states that students use digital media outside of school more often to satisfy their needs than in class (see above), the interaction between setting and motive paints a more differentiated picture, as shown by Figure 1: The children stated that they used the media outside of school more frequently for entertainment and communication purposes than at school, while no difference was found between the different settings when it came to searching for information and an inverse effect was even observed for learning purposes, as the media were used more frequently in class than outside of school in such cases.

Our results show that schoolchildren's motives for using digital media remained consistent over time and did not show significant temporal fluctuation. Despite the general trend of schoolchildren using digital media more frequently outside of school than in class, the interaction analysis revealed more nuanced differences in the usage practices between these two settings.

3.2 Evaluation of digital media usage (RQ1b)

To assess schoolchildren's evaluation of their media usage, we calculated two separate 2 (setting) × 4 (time) repeated measures ANOVAs for satisfaction with media usage and perceived importance of digital media as dependent variables. In addition, one-sample *t*-tests were used to categorize satisfaction and perceived importance as below-average, average, or above-average (the rating scale's midpoint served as reference level). As shown in Table 2, the test results revealed that satisfaction with digital media usage was consistently above average, both in class and outside of school, and remained high over time. However, no significant differences were found between settings, time points, or their interaction.

In contrast, for perceived importance, there was a significant main effect of setting, indicating that schoolchildren rated digital media usage as more important outside of school compared to in class (see Table 2). In class, media usage was rated as average important, while outside of school, it was rated as above average. There were no significant effects of time or interaction with setting. In summary, the

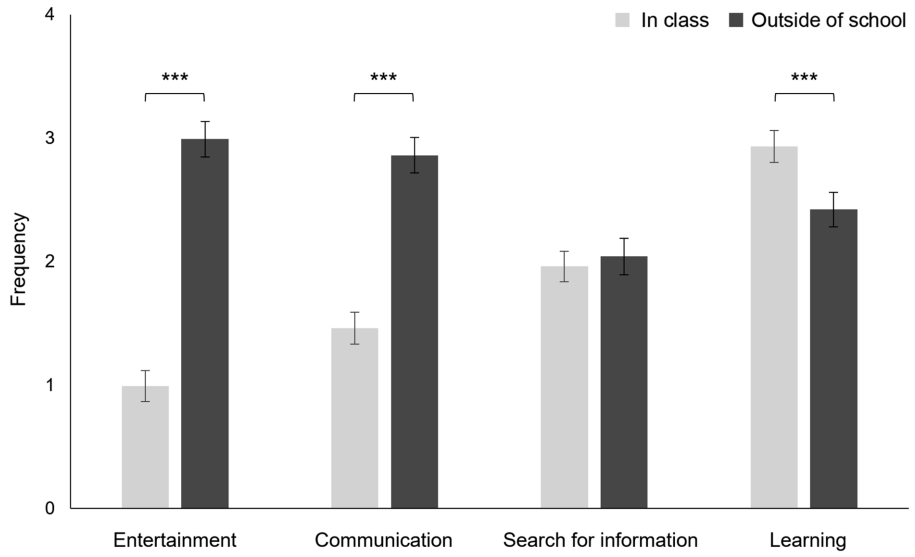

FIGURE 1
Schoolchildren's frequency of motives of digital media usage in class (formal) and outside of school (informal). Each motive was independently assessed. Vertical lines indicate the standard error of the mean. Asterisks indicate the results of Bonferroni contrast between settings for each motive, ***$p < 0.001$.

TABLE 2 Evaluation of digital media usage in class and outside of school across four measurement time points (T1 – T4).

	In class (formal)				Outside of school (informal)				Main effect of setting			Main effect of time			Interaction (setting × time)		
	T1 *M* (*SD*)	T2 *M* (*SD*)	T3 *M* (*SD*)	T4 *M* (*SD*)	T1 *M* (*SD*)	T2 *M* (*SD*)	T3 *M* (*SD*)	T4 *M* (*SD*)	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
Satisfaction (RQ1b)	2.94*** (0.89)	2.88*** (1.00)	2.92*** (1.15)	2.77*** (0.97)	3.13*** (0.84)	3.08*** (0.99)	3.08*** (1.00)	3.06*** (1.04)	3.29	0.076	0.065	0.41	0.747	0.009	0.18	0.910	0.004
Importance (RQ1b)	2.12 (1.39)	2.15 (1.41)	2.33 (1.29)	2.10 (1.31)	2.65** (1.28)	2.77*** (1.17)	2.77*** (1.40)	2.81*** (1.32)	14.35	<0.001	0.234	0.56	0.641	0.012	0.62	0.606	0.013
Perceived learning gains (RQ2b)	1.50** (1.38)	1.23*** (1.31)	1.10*** (1.28)	1.06*** (1.23)	1.15*** (1.15)	1.29*** (1.15)	1.15*** (1.24)	1.27*** (1.36)	0.01	0.917	0.000	0.86	0.466	0.018	3.84	0.011	0.076

Asterisks mark the results of one-sample *t*-tests against the scales' midpoint (2), $^*p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

ratings of digital media usage remained stable over time, with no differences in satisfaction between in class and outside of school settings but a difference in perceived importance between these settings.

3.3 Perceived digital literacy (RQ2a)

We calculated descriptive statistics for perceived digital literacy. The analysis focused on the individual items of the *Media Competence Framework of NRW*. Thereby, we considered only those children who stated that they understood the item and indicated that they had previously engaged in the respective activity. One-sample *t*-tests were conducted to categorize the extent of self-reported digital literacy as below-average, average, or above-average compared to the midpoint of the rating scale. As shown in Table 3, the schoolchildren rated their self-reported digital literacy as above average for almost all of the 24 competence facets. Only the abilities to "assess the credibility of information" and to "recognize algorithms" were rated as average. "Program" was the only competence facet in which the schoolchildren rated themselves as below average. However, and importantly, a substantial portion of the sample experienced difficulties in understanding some of the specific skills or had never engaged in the respective skill before, for example, when it comes to recognizing algorithms, noticing the influence of algorithms, programming, perceiving opportunities and challenges in the digital world, and considering privacy and copyright issues. There therefore appears to be a great heterogeneity in the perception and self-assessment of schoolchildren's own digital literacy, alongside a generally high confidence in their digital literacy among those schoolchildren who (presumably) understand the relevant competence facets.

3.4 Perceived learning opportunities for acquiring digital literacy (RQ2b)

In analogy to the self-assessed digital literacy with 24 facets according to the *Media Competence Framework of NRW* (cf. section 3.3 and Table 3), we focused on 24 corresponding learning opportunities that relate to the six overarching areas of competence. Due to the option for the schoolchildren to indicate that they did not understand a particular item, a notable number of missing data were observed, which are represented by black bars on the right side of each item in Figure 2. As result of these missing data, it was not possible to perform all planned inferential statistical calculations. While repeated measures ANOVA was feasible for analysing the 24 individual learning opportunities, there were insufficient children who responded to all items at all time points for comparisons between and within the six competence areas. Consequently, the comparisons of areas are described descriptively only.

Figure 2 shows the frequency at which schoolchildren consciously perceived learning opportunities to acquire digital literacy in their everyday lives across the four measurement time points. For each learning opportunity (i.e., competence facet), we calculated a repeated measure ANOVA with four measurement time points, excluding schoolchildren who indicated a lack of understanding for the question. In most cases, there was no significant effect of time, indicating that perceived learning opportunities to acquire digital literacy remained

TABLE 3 Self-assessed digital literacy.

Competence area	Subcategory	Item	n^a	*M*	*SD*
Handle and apply	Use digital media	How well can you use digital media (smartphone, PC, laptop, tablet, etc.)?	48	4.27***	0.64
	Use digital tools	How well can you use digital tools (apps, programs, search engines, WhatsApp, etc.)?	48	4.33***	0.60
	Data organization	How well can you store, organize, and retrieve digital information and data?	48	3.58***	0.90
	Protect privacy and personal data	How well can you protect your privacy on the internet and personal data?	43	3.63***	1.00
Inform and search	Information search	How well can you search for information or data on the internet?	48	4.50***	0.58
	Information evaluation	How well can you use information or data from the internet?	46	4.17***	0.61
	Information appraisal	How well can you evaluate information or data from the internet and its sources for credibility?	46	3.24	1.02
	Information criticism	How well can you identify inappropriate or dangerous content on the internet?	46	3.63***	1.06
Communicate and cooperate	Communicate online	How well can you use digital media to communicate with others?	48	4.67***	0.48
	Adhere to communication rules	How well can you follow rules of etiquette on the internet?	45	4.44***	0.69
	Participate in the social society	How well can you use digital media to plan things together with others?	42	4.29***	0.71
	Recognize bullying/cyber violence	How well can you recognize bullying or cyber violence on the internet?	38	3.92***	1.00
Produce and present	Produce, edit, or present	How well can you create, edit, or present media products such as videos, photos, or presentations?	45	3.89***	1.07
	Evaluate media products	How well can you evaluate media products such as videos, photos, or presentations for intent and impact?	42	3.67***	0.87
	Cite sources	How well can you stick to citing sources when using others' images, videos, or text?	40	3.50**	1.16
	Consider privacy and copyright	How well can you stick to getting permission from others before posting images or information from them?	37	4.38***	0.76
Analyse and reflect	Analyse the diversity of the media	How well can you decide which digital medium is best for a particular purpose?	43	3.88***	0.70
	Critically examine the content of media	How well can you critically evaluate the content of media?	39	3.38*	0.91
	Perceive opportunities or challenges	How well can you perceive opportunities and challenges in the digital world?	34	3.65***	0.95
	Regulate the use of digital media	How well can you autonomously stop using digital media after you have had enough of them?	47	3.64***	1.15
Problem solving and modeling	Identify or solve technical problems	How well can you recognize or try to solve technical problems with digital media?	46	3.61***	0.83
	Recognize algorithmics	How well can you recognize algorithmic patterns or structures?	16	3.13	0.81
	Program	How well can you program something?	31	2.13***	1.23
	Notice the influence of algorithms	How well can you notice the influence of algorithms in your everyday life?	23	3.52*	1.16

[a]Calculations were made with $n = 48$ participants, but if n differs, it indicates that the missing schoolchildren either did not understand the question or had never done it. Asterisks mark the results of one-sample t-tests against the scales' midpoint (3), $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

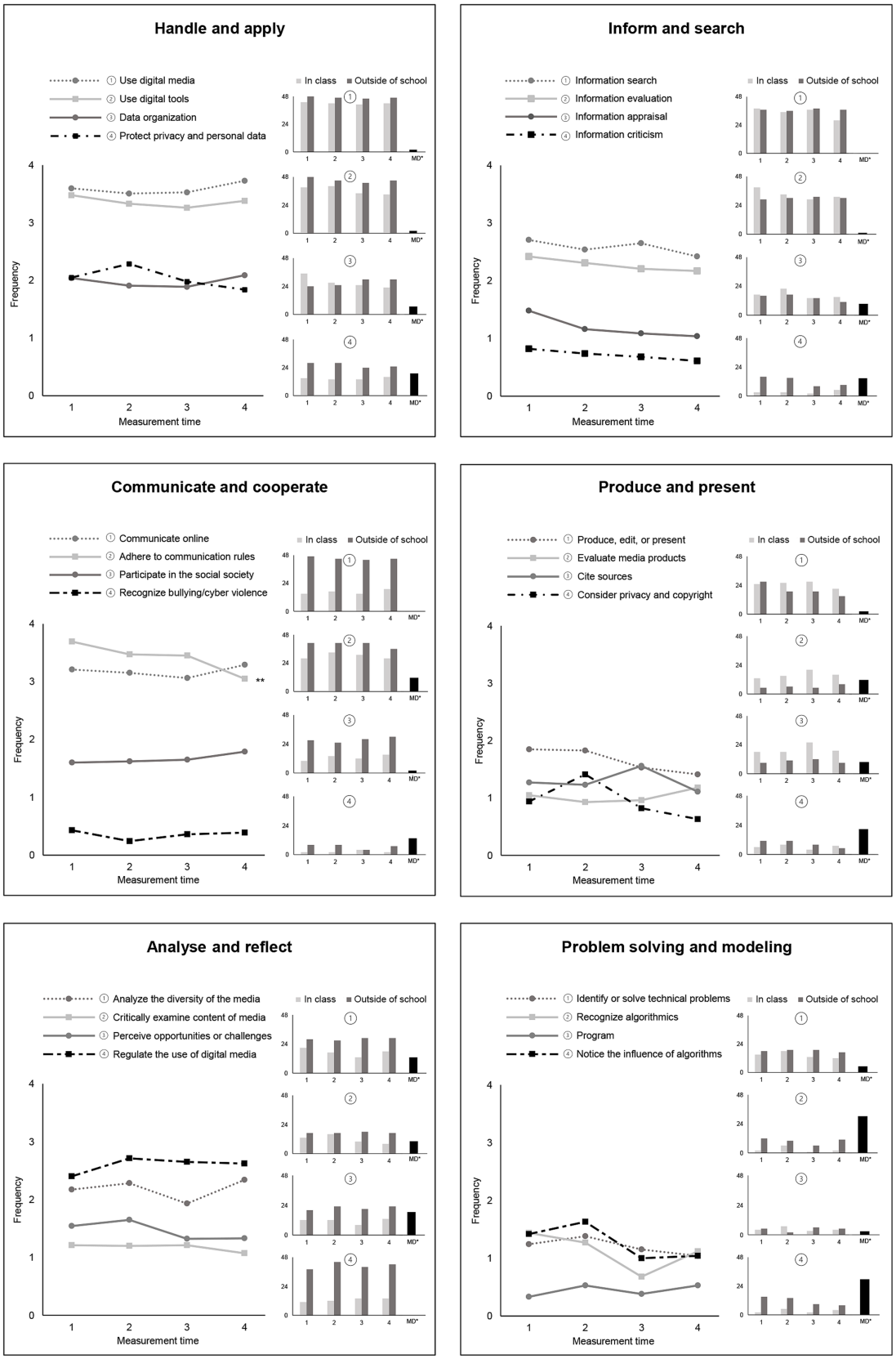

FIGURE 2
The frequency schoolchildren experienced learning opportunities across four measurement time points. Bar graphs on right side present the absolute number of children reporting a specific learning opportunity in class and outside of school. MD* = Missing Data, i.e., the number of children who did not understand the item and were therefore excluded from the respective analysis of variance and mean calculation. $^{**}p < 0.01$.

consistent over time (all $Fs \leq 1{,}98$, $ps \geq 0.120$, $\eta_p^2 s \leq 0.042$). The only significant difference between the measurement time points was observed in the analysis of "adhere to communication rules," $F(3, 108) = 4.11$, $p = 0.008$, $\eta_p^2 = 0.103$, with significantly fewer learning opportunities perceived at the last measurement time point. Due to the small number of schoolchildren, the results were further validated using the Friedman test for nonparametric data, which revealed no significant differences, thus corroborating the findings obtained from the ANOVAs.

Descriptive differences can be observed both within and between the six competence areas. The schoolchildren reported varying frequencies of different learning opportunities. In the first three competence areas ("handle and apply," "inform and search" and "communicate and cooperate"), there were significant differences within the areas. For example, schoolchildren perceived learning opportunities for the first two competence facets of each area ("use digital media," "use digital tools," "information search," "information evaluation," "communicate online," "adhere to communication rules") consistently at a high level throughout the weeks. However, they reported experiencing learning opportunities for the latter two competence facets ("data organization," "protect privacy and personal data," "information appraisal," "information criticism," "participate in the social society," "recognize bullying/cyber violence") much less frequently, and sometimes at a very low level. In the other three competence areas, the differences within the areas were not as pronounced. Learning opportunities for skills in "produce and present" and "problem solving and modeling" were consistently perceived as rare, while there were small descriptive differences within the area of "analyse and reflect" but all of them occurred at a moderate frequency.

Moreover, we found visible descriptive differences when comparing in class versus outside of school regarding perceived learning opportunities. In the first two competence areas, "handle and apply" and "inform and search," there were small to no differences in the frequency of learning opportunities between in class and outside of school settings for most competence facts ("use digital media," "use digital tools," "data organization," "information search," "information evaluation" and "information appraisal"). Only with respect to the competence facets "protect privacy and personal data" and "information criticism" we found a slight difference between the settings, with schoolchildren perceiving corresponding learning opportunities more frequently outside of school than in class. However, in the competence area "communicate and cooperate" a contrasting trend was observed. Schoolchildren reported more learning opportunities outside of school than in class for all four competence facets. In the competence area "produce and present" the differences were more nuanced but also minor. They experienced more learning opportunities in class for the competence facets "produce, edit, or present," "evaluate media products" and "cite sources" but slightly more opportunities for "consider privacy and copyright" outside of school. In the competence area "analyse and reflect" schoolchildren reported slightly more learning opportunities outside of school for the skills "analyse the diversity of the media," "critically examine content of media" and "perceive opportunities or challenges," and considerably more opportunities for "regulate the use of digital media" compared to in-class learning. Finally, in the competence area "problem solving and modeling" learning opportunities for all skills were perceived at roughly the same frequency in class and outside of school, although they were reported very infrequently for all skills. Only for the skill "notice the influence of algorithms," which was not well understood by a higher number of schoolchildren, there was a slight tendency for more learning opportunities outside of school than in class.

Overall, we found no considerably fluctuation across time regarding the perceived learning opportunities for acquiring digital literacy. The schoolchildren consistently reported similar frequencies of learning opportunities across weeks. However, remarkable differences were observed among the various learning opportunities as well as the settings in which they were encountered.

3.5 Perceived learning gain (RQ2c)

To evaluate children's perceived learning gain in dealing with digital media, we calculated a 2 (setting) × 4 (time) repeated measures ANOVA. We found no main effect of time and setting, but a significant interaction between them (see Table 2). Specifically, the two settings differed significantly at the first measurement time point ($p = 0.028$), with no significant differences observed at the later measurement time points (all $ps \geq 0.168$). The schoolchildren indicated that they had significantly learned more in class ($M = 1.50$ $SD = 1.38$) compared to outside of school ($M = 1.06$, $SD = 1.23$) at the first measurement time. The results for both usage settings were below average across all four measurement time points. Hence, despite the availability of learning opportunities in various areas of digital literacy, the perceived learning gain remained consistently low throughout a period of several weeks.

4 Discussion

This study explored schoolchildren's media usage in class and outside of school, as well as temporal fluctuations. The results of the study offer new insights, which we discuss in the following sections, providing valuable implications for both research and educational practices.

4.1 Motives of digital media usage

In line with the U&G approach (Katz and Foulkes, 1962), we focused on need gratification by means of schoolchildren's motives for media usage in class and outside of school. The study findings revealed that motives for digital media usage remained constant throughout the measurement period, with no significant temporal fluctuations. The schoolchildren reported each of the four usage motives (entertainment, communication, search for information and learning) with equal frequency over several weeks. These results are consistent with the biennial representative JIM study (MPFS, 2016, 2017, 2018), which has repeatedly reported similar results across different children and age groups for several years. Our study reproduced these findings over a shorter and more finely resolved period, further supporting the stability of need gratification using digital media. Regarding the differences and similarities in motives for digital media usage between class and outside of school, our study yielded comprehensive insights. Similar to the findings of Wang et al. (2014), we observed variations in motives for digital media usage between these two settings, while also identifying shared aspects. Notably, schoolchildren reported a

higher frequency of utilizing digital media for entertainment and communication purposes outside of school versus in class, whereas learning activities were more prevalent in class. In addition, the schoolchildren stated that the search for information as a motive for media usage occurred with comparable frequency in class and outside of class, consistently throughout the entire survey period.

Furthermore, we found differences between the motives. Specifically, learning was the most frequently mentioned motive across both settings. However, when considering the in-class and out-of-school settings separately, distinct patterns emerged. Outside of school, schoolchildren used media most often for entertainment, communication, and learning, while searching for information was reported less frequently. These findings align with those of the JIM study (MPFS, 2018), which also found communication and entertainment to be mentioned with equal frequency and search for information to be less prevalent. In contrast, in class, the motives for digital media usage exhibited clear gradations, with learning being the most frequent motive, followed by information search, communication, and entertainment. The observed disparity in the fulfillment of needs between formal and informal settings underscores the substantial impact of teachers and their instructional methods on schoolchildren's utilization of media within educational settings. Empowering pre-service teachers through comprehensive training during their academic studies and providing ongoing professional development for in-service teachers is essential. This emphasis is particularly aimed at enhancing their proficiency in effectively integrating digital media into the curriculum. This effort could contribute to a better understanding among teachers of how to address various motives of schoolchildren, thereby making learning in school more relevant and engaging. Teachers could strategically integrate digital media to align with the motives of schoolchildren, ensuring that these resources are both entertaining and educational simultaneously. One potential approach could involve the incorporation of gamification elements. This perspective finds support in a study by Rüth et al. (2022), which revealed a strong association between pre-service teachers' intentions to integrate digital games into educational settings and their perceptions of the games' utility and alignment with the curriculum. This reinforces the viewpoint that teachers can significantly affect the ways in which schoolchildren engage with media and underscores the need for ongoing professional development to bridge the gap between in-class and out-of-school learning experiences (Kumpulainen et al., 2010; Banks et al., 2007).

4.2 Evaluation of digital media usage

We examined the schoolchildren's evaluation of their digital media usage. Our aim was to explore whether there are differences in satisfaction with digital media usage and in the perceived importance of digital media usage between in class and outside of school, as well as any potential temporal fluctuations in these evaluations. This aspect holds significance as per the U&G approach, where the continuous usage of media hinges on its ability to fulfill the anticipated gratification sought initially (Palmgreen and Rayburn, 1982). It is only when (digital) media usage meets the expected gratification that individuals are likely to persist in using it to satisfy similar needs (Palmgreen, 1984). The results of our study showed that there was no significant difference in satisfaction between formal and informal media usage. In addition, satisfaction levels remained high over several weeks, both in class and outside of school. Regarding the perceived importance of digital media usage, we found a significant difference between the settings. The schoolchildren rated the importance of digital media usage lower in class compared to outside of school. Again, there were no significant fluctuation in perceived importance of media usage over time.

The U&A approach is an expectancy-value account, that is, the perceived gratification potential of media usage results from the expected (need-associated) outcome of media usage and its valuation. Given comparable (and time-invariant) satisfaction ratings with, but different importance ratings of media usage in class versus outside of school, we may speculate that schoolchildren have fundamentally different needs-associated expectations of media usage regarding the two settings, and that reduced expectations in class can be adequately satisfied by a reduced offer. In other words, it remains unclear whether the gratification sought through media consumption is at a different level in the two settings and can therefore be satisfied to the same extent by different consumption quality and intensity. This possibility should be further investigated in future research.

4.3 Perceived digital literacy

Remarkably, the schoolchildren perceived their own digital literacy to be above average in almost all competence areas and facets described by the *Media Competence Framework of NRW*, except the competence facets "information appraisal," "recognize algorithmics," and "program." This consistently high self-assessment of digital literacy may suggest that schoolchildren tend to overestimate their own competence. This finding aligns with previous research by Nygren and Guath (2019), who suggested that self-reported surveys on digital skills may not provide an accurate reflection of true abilities. In their study, students reported their skills in seeking and evaluating information as good or great, but when tested on their ability to detect fake news, less than half answered the questions correctly. However, it should be noted that although such information literacy is itself a complex construct (cf. Trixa and Kaspar, 2024), the digital literacy operationalized here encompasses significantly more areas of competence. Yet, also Porlán and Sánchez (2016) as well as Sciumbata (2020) found that students tend to overestimate their digital skills. Based on the available data, we cannot assess the extent to which the self-assessment of digital literacy may have been distorted in the present study. Nonetheless, the present data provide some valuable insights:

Firstly, the schoolchildren did not uniformly rate themselves positively across all competence facets. This observation suggests the absence of a general positivity bias in their self-assessments. Secondly, a substantial portion of the sample experienced difficulties in understanding some of the specific skills or had never engaged in the respective skill before, for example, when it comes to recognizing algorithms, noticing the influence of algorithms, programming, perceiving opportunities and challenges in the digital world, and considering privacy and copyright issues. This result shows the need and challenge to create learning opportunities at school, particularly in the respective areas of competence, in which the very heterogeneous competence levels of class members can be adequately addressed. Thirdly, knowledge of students' self-assessments is *per se* of great value

to teachers, as they can be compared with objective performance and enable a realistic self-efficacy and competence assessment to be established. Fourthly and finally, the self-assessments determined here may also help to identify cognitive processes that lead to the manifestation of such self-assessments. In this sense, one plausible explanation could be that the third-person effect influences self-assessed digital literacy. The third-person effect, as posited by Davison (1983), refers to the inclination of people to perceive media messages as having a more substantial impact on others than on themselves. For instance, teenagers did believe that they are less susceptible to influence by YouTube compared to their peers (Zimmermann et al., 2020). It is possible that children assess their own abilities by comparing themselves to others while simultaneously underestimating the capabilities of their peers. If schoolchildren tend to overestimate their own abilities, this has significant pedagogical implications. Indeed, overestimation can be problematic as it may hinder the development of crucial competencies (Jeffrey et al., 2011). Therefore, it is essential for teachers in schools to be aware of this phenomenon and engage in open discussions with students about potential self-overestimation. Furthermore, it is crucial for teachers to possess higher levels of media literacy compared to the students, enabling children to develop more realistic self-assessments. A representative study found that the majority of 14-to 21-year-olds believe that teachers are not as well-equipped (46%), or even bad (20%) in handling digital learning and teaching methods (Groß, 2019). Universities play a pivotal role in strengthening the media literacy of pre-service teachers to address this issue effectively. Nevertheless, it is important in terms of self-efficacy that children also believe in themselves and do not underestimate their abilities. The theory of self-efficacy (Bandura, 1977) states that confidence in one's own abilities is a crucial factor for an individual's motivation and actions (Wang et al., 2019). If children underestimate their abilities, they may miss valuable opportunities for growth. Therefore, it is important for children to develop a realistic understanding of their abilities that considers both their strengths and areas where they can grow.

4.4 Perceived learning opportunities for acquiring digital literacy

We explored perceived learning opportunities for acquiring digital literacy. In analogy to the self-assessed digital literacy with 24 facets assigned to the six competence areas of the *Media Competence Framework of NRW* (see Table 1), we focused on 24 corresponding learning opportunities in class and outside of school. The data revealed that the frequencies of perceived learning opportunities remained relatively consistent throughout several weeks. There was only a slight temporal fluctuation in perceived learning opportunities regarding one out of 24 competence facts ("adhering to communication rules").

However, our findings indicate substantial differences in the frequency of learning opportunities across the competence areas. These differences were observed both within and between each area. In the "handle and apply" area, high levels of learning opportunities were reported both in class and outside of school. However, some children experienced difficulties in understanding the concept of "protecting their privacy." In the "inform and search" area, the perceived learning opportunities were at an intermediate level. Learning opportunities for the competence facet "information criticism" was reported at a very low level, with responses indicating that this skill was mainly developed outside of school. Some children also indicated comprehension problems in this area. Our findings in the "communicate and cooperate" area align with the gratification to use digital media for communication, as they predominantly occurred outside of school. The skill to "recognize bullying/cyber violence" was infrequently reported by the children throughout several weeks. This observation could suggest that either they had limited exposure to such content or that they struggled to recognize or address it. In the area of "produce and present," the overall level of learning opportunities was perceived as relatively low, with slightly more engagement observed in class compared to outside of school. However, with respect to the specific competence facet "consider privacy and copyright," some children exhibited comprehension problems. In the "analyse and reflect" area, the perceived learning opportunities were consistently at a low to medium level. Approximately half of the schoolchildren encountered comprehension problems with the item related to "perceiving opportunities or challenges." Generally, learning opportunities for all four competence facts in this area were reported more frequently outside of school compared to in-class settings, with the largest difference observed regarding "regulating one's own media use." In the "problem solving and modeling" area, all learning opportunities were reported very rarely compared to the other competence areas, making it the least frequent area overall. However, it is important to note that this area also had the highest number of comprehension problems, particularly with the two facets related to algorithms. This could be attributed to the young age of the study population, some of whom had recently transitioned from elementary school to the fifth grade. It is worth mentioning that computer science is still not a mandatory subject in elementary schools in Germany (Humbert et al., 2020).

The correspondence between consciously perceived learning opportunities and objectively received learning opportunities remains uncertain. It is possible that the learning opportunities offered may not align with the actual extent of learning opportunities utilized by the schoolchildren. This can be explained by the offer-use model proposed by Fend (2002) and further developed by Helmke (2012). According to this model, provided learning opportunities may be subjectively perceived differently by the schoolchildren. Nevertheless, the results of Jäger-Biela et al. (2020) found that there are similar difficulties in implementing learning opportunities for digital literacy in university teacher trainings. Their study, which also employed a questionnaire based on the *Media Competence Framework of NRW,* revealed that the first three areas of the framework exhibited more learning opportunities compared to the areas "analyse and reflect" and "problem solving and modeling." Our findings on learning opportunities therefore do not appear to be limited to young schoolchildren, but also extend to formal learning opportunities for prospective teachers at universities. It therefore seems urgent to change this situation, as it may be difficult for future teachers to provide their students with the learning opportunities they never had during their own education.

In conclusion, our findings have important implications for school practice. Overall, there is significant potential for more learning opportunities in the competence areas of "produce and present," "analyse and reflect" and "problem solving and modeling." On one hand, we identified some schoolchildren who still faced difficulties with the concepts in these three areas, and on the other hand, the skills are

insufficiently practiced in class. In contrast, in the competence areas of "handle and apply," "inform and search" and "communicate and cooperate," there seem to be notably more learning opportunities in class. However, these opportunities are more focused on superficial skills (e.g., "information search") and less on deeper skills (e.g., "information criticism"). Although digital media seem to be increasingly integrated into schools, there is still potential for deeper utilization in some areas.

4.5 Perceived learning gains

We finally explored the perceived learning gain in using digital media. Once again, we found no significant differences between the measurement time points, indicating a consistent subjective learning gain over several weeks. Furthermore, no significant differences were observed between the formal and informal setting. Throughout the entire period, the self-reported learning gain remained consistently low. Only in the first measurement time point was a significant difference observed between the learning gain in class and outside of school, with the classroom perception being slightly higher. Despite the self-reported learning gain being significantly low, it should be noted that this subjective assessment may not accurately reflect the actual amount of knowledge acquired by the schoolchildren. This may be since the children already perceive their own media literacy as very high, as we have already demonstrated in this study. It is crucial to emphasize that we did not measure actual learning outcomes. The study focused on conscious learning, which excludes implicit learning. Implicit learning occurs casually and without a conscious intention to learn (Stern and Schumacher, 2007). Therefore, one possibility is that the schoolchildren were not fully aware of their own learning processes. The children may have difficulties adequately reflecting on and verbalizing their learning experiences. This could indicate that in the education of digital literacy, it is not just about the acquisition of skills but also about developing self-reflection abilities to better recognize and evaluate their own learning. Another possibility for the result of low learning gains could also be that the schoolchildren actually learned little about digital media during the time period. This may suggest that there is still a lack of targeted digital education in both in class and outside of school. This could be attributed to the insufficient alignment of curricula and teaching methods with digital media or possibly to teachers not having adequate media literacy to effectively incorporate digital media into their teaching (Wang et al., 2014). To determine whether schoolchildren learning little about digital media or if it is rather an unconscious learning process, we recommend further studies that investigate both self-reports and the curriculum content simultaneously.

4.6 Limitations

The present study has several advantages and novel aspects, such as comparing media usage in different settings over a period of several weeks and covering a wide range of media activities. However, we must mention some limitations of the study.

First, the study relied on self-assessments and perceived learning opportunities and did not allow for a detailed analysis of actual use behavior or the effect of actual learning opportunities. However, it aligns with the core premise of the U&G approach that individuals consciously perceive their needs and motives for media use (Katz and Foulkes, 1962), making self-reports an appropriate measurement tool. Additionally, it is essential for practical applications and research to understand what individuals themselves think and how their media usage is consciously influenced. To mitigate the risks associated with self-reports, the study employed the media diary method, which helps to minimize recall errors (Bolger et al., 2003) and which can provide a reliable and valid measurement of media usage (Juster, 1986; Juster and Stafford, 1991; Bolger et al., 2003).

Second, the study faced challenges with the sample selection, as it relied on a convenience sample comprising schoolchildren from one school, which could introduce potential sampling bias. Although this sample included schoolchildren from various classes ranging from 5th to 10th grade, representing a diverse age group within the school, the fact that all participants came from a single school limits the generalizability of the findings. It is conceivable that other schools and countries adhere to different curricula regarding digital media, leading to differences in learning opportunities for schoolchildren. Since the NRW Media Competence Framework aligns with the European Digital Competence Framework for Citizens (DigComp 2.1; Carretero et al., 2017) and the Digital Competence Framework for Educators (DigCompEdu, Redecker, 2017), there is a rough consensus across European countries regarding the competence facets that make up digital literacy. However, this does not necessarily mean that the translation of these programmatic frameworks into the specific curricula must be identical; rather, a wide variety in the corresponding learning opportunities at schools is conceivable. However, and importantly, our findings regarding leisure media usage support studies from entirely different countries (e.g., Hong Kong: Lu et al., 2016; Canada: Steeves, 2014). As a next step, future research could specifically target potential differences between schools and countries, with the individual teacher playing a significant role in the concrete design of learning opportunities for the acquisition of digital literacy (cf. Rüth et al., 2022).

Moreover, the high drop-out rate of participants resulted in a relatively small final sample size. Additionally, the absence of incentives for study participation may have led only the most motivated schoolchildren to take part in the study. This could potentially impact the generalizability of the findings. In this context, it seems important to note that despite the extensive efforts invested in the research project, recruiting schoolchildren proved to be exceedingly difficult. In Germany, conducting empirical research within school settings requires approval from school authorities after involving the school conference (Groot-Wilken, 2022). Following positive consent, each investigation necessitates parental consent, and of course, the children must willingly choose to participate. Although the COVID-19 pandemic, during which this study was conducted, allowed for parental contact via email, it did not significantly reduce the high drop-out rate of their children. Thus, future longitudinal research must carefully consider strategies to increase schoolchildren' motivation and compliance. One approach might involve fostering direct face-to-face interactions, which could potentially yield more favorable results compared to online approaches. Additionally, offering incentives or rewards for participating in the weekly diary entries could significantly increase the attractiveness of study participation, leading to a more diverse sample.

Third, no competency test for digital literacy was employed due to the lack of valid tests covering multiple areas and age groups. This

raises questions about the actual level of digital literacy among the schoolchildren and whether they may have overestimated their abilities. The same uncertainty applies to the learning gain, as it remains unclear if the schoolchildren learned so little or simply did not consciously recognize their learning progress. Some participants experienced difficulties understanding the wording related to digital literacy, and it is unclear whether this was due to linguistic or subject-specific issues. However, as outlined above, not only despite, but precisely because of the lack of available objective performance measures and measurement tools, we have focused on self-assessments. Although the questionnaire we utilized may not be an established measurement instrument, it was grounded in theoretical principles, with content validity ensured through alignment with the *NRW Media Competence Framework*. A similar approach was also employed by König et al. (2020), who investigated the adaptation of teachers to online teaching during the COVID-19 school closures in their study and utilized the competence framework as the basis of their survey. In the present study, the wording of the items was adapted to suit schoolchildren, aiming for simplicity and clarity. While the framework provides a structured approach to assessing media literacy, it is not without its limitations. Firstly, the framework is designed to be broadly applicable across different educational contexts and age groups. This generality, while useful for wide application, may lead to a lack of specificity for certain subgroups or particular age ranges, potentially overlooking unique aspects of digital literacy in those groups. Secondly, the rapid evolution of digital technologies means that the framework might not always keep pace with the latest developments. This lag can result in certain competence facets being underrepresented or outdated, impacting the relevance and comprehensiveness of the assessment. Finally, the adaptation of the questionnaire items for schoolchildren, while aiming for simplicity and clarity, may have led to a loss of nuanced understanding of certain competence facets. The wording of the items might not have captured the full complexity of some digital literacy skills, leading to potential misunderstandings or oversimplifications. In conclusion, while the *NRW Media Competence Framework* provides a valuable foundation for assessing digital literacy, these potential limitations, which also apply to comparable framework (cf. Carretero et al., 2017; KMK, 2016; Redecker, 2017), highlight the need for ongoing refinement and validation of instruments that are conceptually based on such frameworks. Future research should consider these limitations and aim to develop comprehensive and adaptable tools to objectively measure digital literacy across diverse educational contexts and age groups. In this context, it is important to note that our approach also considered the practical aspects of measurement efficiency. By emphasizing economy, we aimed to ensure that the instrument could be used repeatedly without imposing excessive burdens on children. This dual focus—capturing a comprehensive picture of children's media usage behaviors while ensuring practical efficiency—is a major challenge that has to be overcome in the context of research during ongoing school operations.

4.7 Practical implications

4.7.1 Implications for practice

Based on the findings, we can derive three implications for practice, specifically for school teaching and teacher education.

The first implication is to foster comprehensive digital media literacy, emphasizing not only its usage but also promoting critical engagement and deepening knowledge. The study revealed variations in understanding among schoolchildren regarding the questionnaire items, emphasizing the need for clear identification of learning opportunities to raise awareness of the skills. Especially with younger schoolchildren, simpler language is necessary to explain complex terms such as "algorithms." This can be achieved by explicitly specifying the exact activities carried out with digital media to introduce technical terms and concepts. The results indicate differences and areas for improvement in various areas of media literacy. Schools should develop targeted programs and activities to enhance schoolchildren' skills in these areas. This can be achieved through the integration of digital media education into the curriculum.

The second implication is the need for greater integration of digital media into classroom instruction. The study findings reveal that schoolchildren frequently engage with digital media for communication and collaboration outside of school. This presents an opportunity for schools to leverage digital media within the classroom to enhance learning and collaboration. To achieve this, schools can incorporate online platforms, collaborative tools, and multimedia materials into their instructional practices. Furthermore, schools have the potential to integrate serious games, which are video games designed for educational purposes, into their teaching methods. Serious games offer various advantages for instruction (Clark et al., 2015; Tsai and Tsai, 2020). By incorporating serious games, schools can create dynamic and interactive learning environments that promote schoolchildren engagement and motivation. Nonetheless, it is essential to consider that personal variables can impact how learners perceive and interact with the same learning offerings (Kaspar et al., 2023).

The third implication arising from our findings is the necessity to enhance teacher professional development. Considering the significance of digital media literacy, it is crucial for universities to provide opportunities for professional growth among pre-service teachers. Educators should be kept up to date with the latest trends and advancements in digital media and be equipped with the skills to effectively incorporate them into their teaching practices. Professional development initiatives can encompass training on the utilization of digital tools, fostering critical media reflection, and designing learning activities centered around digital media. This finding aligns with the research of Wang et al. (2014), which underscores the importance of teacher training in integrating media into schools to enhance schoolchildren' digital skills. Compared to students from other disciplines, German pre-service teachers, both before and during their advanced studies, demonstrated lower levels of digital competence (Senkbeil et al., 2020). Therefore, university education programs should expand their offerings of comprehensive digital learning opportunities to better equip pre-service teachers for utilizing media in educational settings. On the European level, the *DigCompEdu* (Redecker, 2017) serves as a valuable reference. The aim of the *DigCompEdu* is to assist teachers in enhancing their digital competences, promoting the use of digital technologies and media in education, and improving the quality of digital teaching. The framework covers various areas of competence that educators need in order to effectively integrate digital technologies into their teaching.

TABLE 4 Summary of the key findings and implications of this case study.

	Key findings	Theoretical implications	Practical implications
Motives of digital media usage (RQ1a)	Significant differences in digital media usage motives were observed between in-class and outside-of-school settings. Schoolchildren reported a higher frequency of digital media usage for entertainment and communication purposes outside of school compared to in class, while learning activities were more prevalent in class. There was no difference in the use of digital media for information search	Variations in motives highlight the influence of setting on media usage preferences and behaviors. Need fulfillment occurs both formally and informally	Educators should strategically integrate digital media into the curriculum to align with schoolchildren's motives, enhancing engagement and relevance of the learning content. This process can be facilitated by initiating conversations with schoolchildren to understand their specific digital media needs and preferences, fostering a more tailored and effective integration of digital resources into teaching practices. One potential approach could involve the incorporation of gamification elements
	The motives for digital media usage remained constant over time, showing no significant temporal fluctuations	Motives that influence the choice and use of media are relatively stable on different time scales, so that need gratification according to the U&G approach should continuously affect the behavior of learners. On the other hand, there might be a greater temporal fluctuation when more specific motive facets are taken into consideration instead of the relatively broad motive categories used here	The stability of motives implies that interventions targeting digital media usage should take into account the fundamental relevance of certain categories of motives in a given setting, but temporal fluctuations are rather negligible
Evaluation of digital media usage (RQ1b)	No significant differences in satisfaction between in-class and outside-of-school settings: Schoolchildren reported high satisfaction with digital media usage both in class and out of school	The result indicates that the satisfaction of needs through digital media remains stable regardless of the setting. This supports the assumption that the satisfaction sought through the use of digital media is tuned to the respective setting so that unrealistic expectations are prevented (provided the setting is sufficiently familiar)	Educators can use schoolchildren' satisfaction to motivate them positively, even when dealing with challenging topics. By acknowledging and building on schoolchildren' positive experiences with digital media, educators can tailor their teaching methods to match these preferences, creating a more engaging learning atmosphere. Additionally, educators can explore creative ways to incorporate digital media into lessons based on schoolchildren' satisfaction, crafting activities that resonate with their interests and how they like to learn
	Schoolchildren indicated a high perceived importance of digital media both in class and outside of school, with higher ratings recorded outside of school	This result imply that digital media play a significant role in schoolchildren's lives beyond traditional educational environments. This finding also underscores the need for a broader understanding of the socio-cultural factors influencing the perceived importance of digital media, as well as their implications for learning and development	Educators should recognize the considerable role that digital media play in schoolchildren's lives both in and outside of school. Acknowledging the higher perceived importance of digital media outside the classroom can inform curriculum design and teaching practices, encouraging the integration of digital resources that resonate with schoolchildren' experiences and needs beyond the school setting
	Satisfaction with and perceived importance of media usage remained consistently high over time	Given that the U&A approach is an expectancy-value account, time-invariant ratings of satisfaction with and importance of media usage may reflect successful adaptation of expectations to the need gratification potential of certain media in certain settings. It is unclear how resistant these modes are to unfulfilled expectations	Conversations with children about the importance of digital media could provide valuable insights into where they perceive its use to be most critical. Such discussions may inform educators' decisions regarding the integration of digital tools and resources, ensuring that they align with schoolchildren' perceived needs and priorities

(Continued)

TABLE 4 (Continued)

	Key findings	Theoretical implications	Practical implications
Perceived digital literacy (RQ2a)	Schoolchildren perceived their digital literacy to be relatively high across various competence facets, as indicated by their self-assessment	This finding may indicate the presence of the third-person effect, where individuals perceive themselves as more digitally literate compared to their peers. This phenomenon underscores the complexity of self-assessment and the need for further research to explore the underlying (cognitive) factors shaping schoolchildren's perceptions of their digital skills	Teachers should be aware of the potential for schoolchildren to overestimate their digital literacy. Thus, teachers should engage in open discussions with schoolchildren about self-assessment and its implications. Moreover, fostering realistic self-assessments among schoolchildren can contribute to their self-efficacy and motivation for learning and skill development. Additionally, teachers should possess higher levels of media literacy themselves to effectively guide schoolchildren in developing realistic self-assessments. Universities play a crucial role in enhancing the media literacy of pre-service teachers to ensure they are equipped to address the complexities of digital literacy in educational settings
Perceived learning opportunities for acquiring digital literacy (RQ2b)	Significant differences were observed among the various learning opportunities and settings	Learning opportunities regarding the different competence facets of the media literacy framework seem to be encountered quite differently. This could (partly) explain the visible discrepancies in the perceived level of competence across domains	Educators could clearly explain to schoolchildren which skills are being used in tasks with digital media and name them specifically. By doing this, they help schoolchildren understand different aspects of media literacy and encourage them to develop and use these skills regularly
	Perceived learning opportunities to acquire digital literacy remained relatively constant over time	This result might indicate the (relative) stability of the learning environment	Here we see an opportunity for educators to address topics that may not typically be covered in everyday teaching. By focusing on areas where learning opportunities are perceived to be less frequent, educators can tailor their teaching strategies to provide more targeted and effective instruction in those areas
Perceived learning gain (RQ2c)	The perceived learning gain for both in-class and out-of-school settings was rated below average across all measurement time points	Although schoolchildren reported many learning opportunities, the perceived learning was at a low level. Future research should therefore disentangle subjective from objective (including unconscious) learning gains	Merely integrating media into the classroom is insufficient to generate a sense of learning gain. It is therefore essential to clarify to schoolchildren what they have just learned using digital media
	There was no main effect of time or setting, but a significant interaction was observed between them. At the first measurement time point, schoolchildren reported significantly higher perceived learning gain in class compared to outside of school	Across all examined variables, only in perceived learning gains was there a temporal fluctuation, indicating the potential for further longitudinal studies in this area	Educators could track with schoolchildren what they have learned about digital media and bring learning gain from everyday life into the classroom

4.7.2 Practical implications for future research

Our case study provides valuable starting points for future research endeavors in the field of digital media. Conducting studies at schools in Germany entails numerous challenges. Conditions and requirements can vary from one federal state to another. In North Rhine-Westphalia, where the study took place, obtaining approval from the school administration was necessary, involving presenting the proposal at a school conference for approval. This process requires significant time and planning before the study can even commence (BASS, 2024). Additionally, schools are often very busy, leaving little time for recruitment efforts. Therefore, careful consideration of study economics and thorough planning is essential. Obtaining parental consent for minors also requires significant time and reminders. Ethical approvals can increase the trust and openness of schools and parents. Although psychological studies in Germany do not necessarily require ethical approval, we recommend it, especially for studies involving minors.

In future studies, consideration should be given to incentivizing participation. While we consciously chose not to offer incentives to maintain the voluntary nature of the study, incentives could indeed enhance participation rates. However, it is crucial to balance this potential benefit with the risk of compromising the voluntary nature of participation (Singer and Bossarte, 2006). Additionally, the type and magnitude of incentives should be carefully considered to ensure they do not unduly influence participants' decision-making processes or introduce biases into the study results.

The ongoing COVID-19 pandemic forced us to change our original plan of weekly school visits. Instead, digital contact was established to ensure anonymity and safety, which may have contributed to drop-out rates. For future studies, researchers should consider personal visits to schools to collect media diaries. The length of the weekly surveys can also contribute to drop-out rates. We aimed to minimize the burden on schoolchildren by keeping the media diaries as brief as possible. Future studies should prioritize brevity to prevent drop-out.

As our study was limited to four weeks, it is essential to extend the research over a more extended duration to gain a more complete picture of the changes and developments in schoolchildren' digital media usage. Regular evaluations can serve as valuable tools for monitoring progress and identifying areas in need of improvement in digital media literacy. These evaluations can provide valuable insights that can inform appropriate actions and interventions to enhance schoolchildren' digital media skills and competencies. However, it is important to note that extending the duration of the study would likely result in seasonal peaks related to certain events such as exam periods or major events. During the time we conducted our measurements, we were able to keep these events as consistent as possible, making it suitable for establishing a baseline. Nonetheless, these peaks could also be of interest and should be taken into account when planning further studies.

The final implication pertains to the development of valid test procedures to assess objective digital literacy. We repeatedly emphasized the importance of having reliable and valid tests that can accurately measure schoolchildren' digital literacy skills. Such tests are beneficial for both research and school practice. Schools can utilize objective tests to assess the effectiveness of their teaching methods and identify areas where schoolchildren may require additional support. Furthermore, objective tests can promote critical self-reflection among schoolchildren, enabling them to gain insights into their own digital literacy skills. It is crucial that these tests employ clear and age-appropriate content and tasks to ensure accurate measurement of schoolchildren' digital literacy.

4.8 Conclusion

The present case study provides first and some unique insights into the use of digital media in class and outside of school over several weeks. The findings emphasize the necessity of comprehensive digital media education for schoolchildren. Table 4 presents an overview of the main findings along with their theoretical and practical implications. In conclusion, the study highlights the crucial role of schools and teachers in providing targeted digital media education. This will enable schoolchildren to make realistic assessments of their digital skills and promote meaningful use of digital media both inside and outside of school.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://dx.doi.org/10.4232/1.14225 (Kaspar and Meier, 2024).

Ethics statement

The studies involving humans were approved by Ethics Committee of the Faculty of Human Sciences at the University of Cologne (KKHF0106). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

JM: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft. KK: Funding acquisition, Resources, Supervision, Methodology, Project administration, Validation, Writing – review & editing, Conceptualization.

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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.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1379755/full#supplementary-material

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