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ORIGINAL ARTICLE

Digital Media at the Out-of-school Learning Place - A Qualitative Interview Study with Prospective Science Teachers

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ABSTRACT

Children and young people grow up with a wide range of media, which they are expected to use in different settings. One possibility is the use of digital media in out-of-school learning places, which is currently being expanded. However, there has been little research into the combination of the two fields to date. This study was designed to address this research gap. The study focuses on the opinions and attitudes of prospective primary school teachers on this combination. This is of great importance as, due to current developments, prospective teachers could often find themselves in the situation of being able or having to combine the two fields. 20 prospective teachers (M =23 years, SD = 2.6) took part in the interview study. All prospective teachers have a positive attitude toward digital media. However, most of them are very critical of their use in out-of-school learning places. However, they can name some possible applications and advantages. On the other hand, there are hurdles such as technical problems or their missing skills.

KEY WORDS: Digital learning; digital media at out-of-school learning places; prospective science teachers for primary schools

INTRODUCTION

The omnipresence of digitalization has an enormous impact on the everyday lives of students, meaning that the educational process is also constantly changing (Reichwein, 2021). Children and young people grow up with a wide range of media; smartphones, laptops, and televisions are common in almost all German households (mpfs, 2022a; 2022b). This is at a similarly high level in other industrialized countries worldwide (Bernath et al., 2020; Ofcom, 2021; Rideout and Robb, 2020). In the private sphere, children in Germany spend more than 3 h a day with digital media such as television, smartphones, and tablets (mpfs, 2022b; Ofcom, 2023b). Media use is also increasing globally. This mainly relates to digital media (YouGov, 2022). One of the reasons for this will be that digital media are easy and intuitive to use and offer a wide range of learning opportunities (Dorouka and Kalogiannakis, 2024; Neumann and Neumann, 2014)

This is not the only reason why it is essential to develop students' media skills at an early age and to lay the foundation for further media education in primary school (Herzig, 2020). In addition, access to information, communication options, and participation in society are strongly influenced by digital possibilities (Glüer, 2021). Teaching media skills that empower students to use media safely, creatively, and responsibly is therefore essential (Medienberatung, 2020). Irion (2018) concludes that media education is already an issue in primary school. It should not be left to chance whether and how primary school children are supported in dealing with the various potentials and risks. A lack of media skills already promotes new and serious social inequalities at primary school age. This should therefore be supported at an early stage.

Another topic that is becoming increasingly important is out-of-school learning places. This means, for example, visiting a laboratory, the forest or a bakery to explore the subject matter in greater depth. The combination of in-school and out-of-school places of learning represents a change in schools in Germany (Budde and Hummrich, 2016). Out-of-school places of learning are also highly relevant internationally for dealing with academic topics (Berg et al., 2021; Uludag, 2021).

The combination of in-school and out-of-school learning is particularly necessary for science lessons in primary school (Blaseio, 2016). The subject of science is especially suitable for visits to out-of-school learning places because, as an integrative and multi-perspective subject, it offers many opportunities to make connections (Dühlmeier, 2022a). However, the two topics are rarely considered together. This is where the following study starts.

THEORY

Digital Media

Media are defined as tools for capturing, storing, processing, and transmitting information. This includes computers, tablets, mobile phones, books, newspapers, but also media content (e.g. software, websites, forums) or corresponding basic components such as texts, images, and videos or a combination of these elements (Mantiri, 2014; Petko, 2020). In the current

discourse, media skills mainly refer to digital media. Digital media are media that store or transmit information digitally using electronic devices and reproduce it in pictorial or symbolic form (Pallack, 2018) or media whose content is based on digital coding in the binary number system (Kersken, 2023). Well-known examples of digital media are computers, laptops, smartphones, tablets, and the World Wide Web (Wahl, 2021). Petko (2020) differentiates between six central functions of digital media use in the classroom: presenting and illustrating, experimenting and practicing, producing and programming, communicating and cooperating, organizing and documenting, and testing and assessing.

The application use and reflection of digital media in the school context offer a wide range of potential and opportunities. Students' media skills are trained continuously (Habermann, 2021). Furthermore, the various different approaches can enable multimedia learning (Mayer, 2014; 2021). The numerous possibilities and tools of digital media can be used for differentiation, in particular, to take into account the individual learning requirements of the students (Hillmayr et al., 2017). In addition, a reference to everyday life can be established (Habermann, 2021). Moreover, the use of digital media can prove to be motivational (Hillmayr et al., 2017).

In contrast to that, the use of digital media has also disadvantages. For example, the use of smartphones can have a negative impact on concentration and attention (Habermann, 2021). In general, digital media can lead to increased concentration and distraction (Aufenanger, 2017). This can result in a reduction in memory performance (Shibata and Omura, 2018). There is also an increasing trend toward the addictive use of digital devices (Habermann, 2021).

The competent use of digital media is a developmental process and a central task of lifelong learning. This should already be trained with younger children (Süss et al., 2018). In primary school, science lessons are particularly suitable for learning with and about digital media due to the world-inclusive core task and the multi-perspective principle. As there are a variety of opportunities to connect as well as learn with and about media (Kunkel and Peschel, 2020). In this way, science lessons can prepare students to become competent, empowered, and also digitally competent in an increasingly globalized and digital world (Schmeinck, 2022). The use of digital media and media literacy can also be learned in informal learning contexts, including out-of-school places.

Out-of-school Learning Places

Out-of-school learning places are characterized by the fact that the learning process takes place outside the classroom and the school campus (Baar and Schönknecht, 2018; Sauerborn and Brühne, 2020). One aim of out-of-school education is to offer students on-site experiences that are not possible at school (Thomas, 2009).

Out-of-school learning places are characterized by a number of advantages: For example, they offer the opportunity for primary and original experiences (Dühlmeier, 2022b; Karpa et al., 2015; Lakin, 2006; Yildirim, 2018). In addition, a connection to the real world can be established and subjective approaches and interests can be taken into account (Baar and Schönknecht, 2018; Lin and Schunn, 2016; Yildirim, 2018). When visiting an out-of-school place of learning, various competences can be addressed, including media competence. Moreover, they offer many opportunities for implementation (Jäkel, 2021), which is the reason why they are more and more being built into school lessons, especially in science lessons. They are therefore becoming increasingly important in education (Deinet and Derecik, 2016; Schwan et al., 2014). The combination of school with out-of-school places of learning represents a change in the German school system (Budde and Hummrich, 2016). This is particularly necessary in science lessons at primary school (Blaseio, 2016). The importance of and demand for out-of-school learning is also increasing internationally (Waite, 2020).

However, visiting an out-of-school learning place is also associated with hurdles. A major challenge for a visit to an out-of-school learning place is the additional time and organizational effort for teachers (Dühlmeier, 2022b; Kuske-Janßen et al., 2020). Internal school coordination and authorizations must also be taken into account (Sauerborn and Brühne, 2020). According to Dühlmeier (2022b) and Kuske-Janßen et al. (2020), the learning place can have a distracting or overwhelming effect on students due to its diverse learning opportunities.

Although there are some hurdles, out-of-school learning places should still be integrated as they provide special access. Due to special requirements, nature experiences can often only be realized at non-formal educational locations (Wilde et al., 2019). The above-mentioned hurdles prevent integration, so it is not possible to organize a trip to an out-of-school learning place for every topic. New digital media such as virtual reality technology can be an innovative way to realize high-quality experiences in the classroom with reference to out-of-school learning places (Büssing, 2021). It can therefore make sense to combine the two topics.

Combination of Digital Media and Out-of-school Places of Learning

Both digital media and out-of-school learning places have many advantages and a high priority in German school policy (see previous sections). Overall, digital media can be a useful addition to out-of-school learning places, even in natural environments. Although real experiences of nature cannot be replaced by digital ones, but they can expand the opportunities for experiencing nature in science lessons (Eckes et al., 2021).

Some learning places such as museums already have integrated digital media in different ways in the past few years, for example: Andraschke and Wagner (2020), Brill and Flügel (2022), Caruso et al. (2020), Horn et al. (2016), Nelson et al. (2020) and Yoon and Wang (2014). There are already first and good examples, which often relate to informal learning

situations (Degner et al., 2022). However, there is still little research on the combination of the two concepts in a school context. In particular, this relates to STEM topics in primary science education.

MATERIALS AND METHODS

Research Questions

Because of the gap in the research dealing with the connection of the two concepts in an educational context, the present study was designed. The study focuses on the opinions and attitudes of prospective primary science teachers on this topic and is to give an initial overview of the new research field. This is of great importance, as prospective teachers could often find themselves in the situation of being able or expected to combine the two topics due to current developments. In addition, the first studies have shown that the use of digital media in out-of-school learning places only had positive effects in terms of knowledge growth (Degner et al., 2022).

The following two research questions will be answered:

1. What potential do prospective teachers see for digital media in out-of-school learning places?
2. What barriers and disadvantages do the prospective teachers see for digital media in out-of-school learning places?

Sample

A total of 20 prospective science teachers took part in the study. Participation in the study was completely voluntary. The mean age of the participants was 23 years (SD = 2.6). Most of the participants were female (female = 18, male = 2). At the time of the interview, 10 students were studying for a Bachelor's degree and 10 students were studying for a Master's degree to become primary school teachers in the subject of science education at a German university. The students had no experience in combining the two topics from their university education. The research questions described were part of a larger study. Therefore, the interviews ranged in length from approximately 7 to 22 min. The interviews were performed in spring 2023.

Interviews

The semi-structured interviews were conducted using an interview guideline. The interview guideline was developed, communicatively validated, and tested based on existing guidelines. It included questions about different aspects of digital media at out-of-school learning places. There were 6 questions in total, such as: *How would you describe the possibilities of digital media at the out-of-school place of learning?* or *What advantages do you see in the use of digital media at the out-of-school place of learning?*

The guideline interview method was chosen because it gives the interview a general structure, but still leaves room for flexibility (Döring and Bortz, 2016). In addition, the interview guide was communicatively validated before the study (Meyer, 2018). Following the interviews, the audio recordings were transcribed and the language straightened (Kuckartz and Rädiker, 2022). To illustrate the results, anchor examples were translated into English. This procedure does not represent a falsification of the material.

Content Analysis

The interviews were then transcribed and analyzed with the content structuring qualitative content analysis according to Kuckartz (2016). All process steps were run through and completed with iteration and feedback steps (Kuckartz and Rädiker, 2022). The categories were mainly formed inductive, which is the most common way. Afterward, a codebook was created for fixation and documentation (Hussy et al., 2013). The entire analysis was carried out with the MAXQDA 2024 software.

To ensure quality, the seven criteria of Steinke (2007) were observed throughout the research process. Since the classic quality criteria cannot be used directly, this guarantees a transparent research process. In addition, ethical principles were observed throughout the entire research process (Hussy et al., 2013). To check the quality of the analysis, the intercoder reliability (Cohen's kappa) between the first and second coder was measured. The second coder was a trained person who was already familiar with the method and the program. According to the literature, 10-20% of the data material should be coded by two coders (Döring and Bortz, 2016). In the present study, 15% was coded by the second coder, based on the codebook. Cohen's kappa was 0.8 and can be classified as substantial (Landis and Koch, 1977).

RESULTS

All 20 interviews were included in the data analysis. In total, more than 150 statements were coded. Initially, the first research question: *What potentials do prospective teachers see for digital media in out-of-school learning places?* is analyzed from different perspectives. The interviews clearly show that all prospective teachers have a positive attitude toward digital media. However, most of them are very critical of its use in out-of-school learning places: "But I don't know any digital medium that I would use in an out-of-school learning place" (A, pos. 41), "I wouldn't go into the forest and take a laptop or a tablet with me. That somehow doesn't make sense to me at that moment" (M, pos. 42) or "I always find the implementation quite difficult" (O, pos. 54). A total of 15 statements argue against using digital media at an out-of-school learning place.

At the time of the interviews, only four persons already had experience with the connection of the two topics. The four experiences are very different and none of them relate directly to science lessons. One person describes an outdoor geocaching rally with other digital elements that they organized with a school class (L, pos. 83). Another person describes digital possibilities such as audio recordings, and videos that they were able to use in a museum to make the exhibitions and the visit more interactive (H, pos. 74). However, all of them had ideas for the implementation of digital media at the out-of-school

place of learning. These could be divided into 4 categories which are shown in the Table 1. This also includes examples and the number of mentions.

Table 1: Categories for the use of digital media at out-of-school learning places with examples and number of mentions in each category

Categories	Examples	Number of mentions
Documentation	You could use the tablets so that the students take pictures of things they discover (C, pos. 38)	26
Tools like apps	There are identification apps: What kind of plants are these? That would of course be a possibility (B, pos. 46)	17
Utilities	I would use the tablet or laptop to write down information and do research (M, pos. 46)	9
Microscopy/ measurement	…a microscope that you can connect to a tablet. That you can simply use to examine objects on location. (J, pos. 34)	5

Most prospective teachers named the use of digital media for documentation in the form of photos and videos. In addition, digital media opens up new possibilities. Various apps, e.g., for plant identification, but also tools, such as measuring instruments and small microscopes can be used and taken to the out-of-school place of learning.

Statements that were only mentioned sporadically were summarized in the category "other." These include, for example, statements about the tablet as a work tool or a digital whiteboard. In addition, three people point out that it is not suitable for promoting media skills and media education.

Similarly, prospective teachers see many advantages for digital media. These include *support* "I think that's a good add-on" (D, pos. 39), *actuality* "that is a very large part of the children's everyday life" (D, pos 37), *relevance for the prospective* "this is important for their prospective as a connection to their living environment " (E, pos. 67) or *motivation* "you also realize that the children really enjoy it" (H, pos. 64). However, they also see only isolated advantages for the use of digital media at the out-of-school place of learning. A total of 13 advantages were named, for example:

- "That they can work with the notes and photos afterward. So that this day can be established in the lessons. That the students can still prepare small projects" (A, pos. 41)
- "It could already help when you are talking about animals or something and you don't necessarily see them in the forest, then you can show them what the animals look like" (N, pos. 44)
- "I think that digital media can be a good networking tool, especially with the out-of-school place of learning" (E, pos. 39)

In relation to the second research question: *What barriers and disadvantages do they see for digital media in out-of-school learning places?* a total of 27 statements could be grouped into 5 categories, which you can see in Table 2.

Table 2: Categories for disadvantages in the use of digital media in out-of-school learning places with examples and number of mentions

Categories	Examples	Number of mentions
Technical conditions	At the out-of-school place of learning, when I go with them to the river or something, I don't necessarily have Wi-Fi (D, pos. 50)	11
Take along	I think at the out-of-school place of learning, if everyone takes their own tablet with them that will be quite difficult. (I, pos. 39)	6
Handling	At the out-of-school place of learning, you have to pay a bit more attention to the things so that they don't fall into the water or something. (K, pos. 69)	5
Limited knowledge	If children are not so good at handling and don't have a table, I could imagine that this could lead to problems. (I, pos. 36)	2
Other	It's a big factor for the children when they are allowed to use digital media. Then they are very focused on it and on the trips they should focus on the environment. And somehow, I just find it difficult to bring them together. (O, pos. 54)	3

Many of the prospective teachers see problems with the technical conditions, such as Wi-Fi or electricity for the devices. Taking them to the out-of-school place of learning and handling them as well as the limited knowledge there is also seen as a challenge. In addition, some general disadvantages of digital media such as *distraction* "that the distraction is quickly there" (L, pos. 91), *risks* "these risks should not be ignored" (A, pos. 35*)*, *screen time* "that children are not only allowed to spend their time with media" (B, pos. 40) or *equipment* can be transferred.

DISCUSSION

In the interviews, the prospective science teachers describe their attitudes and experiences regarding the use of digital media in out-of-school learning places as well as its advantages and disadvantages.

Overall, the prospective teachers have a positive attitude toward digital media. A detailed analysis of the attitudes and opinions of prospective science teachers toward digital media can be found in Wenzel and Blumberg (submitted a). This importance can be explained by the ever-increasing influence of digital media (Kramer and Gabler, 2022). Moreover, this suggests that they will use them later in the classroom (Ajzen, 1991).

They also have a very positive attitude toward out-of-school places of learning (Wenzel and Blumberg, submitted b). However, the attitudes toward using digital media in out-of-school places are rather negative. This attitude could be justified by the fact that it represents an emerging area. In which many developments are currently taking place in parallel and discussions are still ongoing about how useful they are (Hahn, 2020). In addition, there is

hardly any experience in combining media and out-of-school places of learning. Experience often relates to out-of-school places of learning that are organized institutionally, such as school laboratories (Dannwolf et al., 2020; Wejner and Wilke, 2022) or museums (Horn et al., 2016; Yoon and Wang, 2014). The (prospective) teachers are also insecure in using digital media (Schmid et al., 2017; Vogelsang et al., 2019). However, these are all just ideas as to why the prospective teachers have such a critical view. It would be useful to investigate the reasons for this critical attitude in more detail in a further study. However, the participants already have first ideas for a meaningful use of digital media. These mainly relate to documentation at the out-of-school learning place, the use of tools such as apps, utility programs or microscopy and measurement options. These ideas are not very diverse and therefore cannot cover all aspects of media literacy, for example. Media literacy is defined as the ability to use, understand and organize media and communication in a variety of contexts (Ofcom, 2023a; Potter, 2018). However, these results are in line with Kampschulte et al. (2019) and Degner et al. (2022), which also showed that media are primarily used as a means of information and presentation.

Other ideas include digital presentation of objects in the museum with interactive information, co-designing the exhibition with digital evaluations, or augmented reality (Hahn, 2020). These are already being implemented in a variety of ways, but do not yet seem to be present among prospective teachers. Further ideas for using digital media in out-of-school learning venues can be found in Kampschulte (2018).

Furthermore, the general advantages of digital media mentioned are strongly oriented toward literature (Bertelsmann Stiftung, 2015; Hillmayr et al., 2017; Mantiri, 2014). Prospective teachers named only a few other specific advantages of using digital media at out-of-school learning places. These include the possibility to follow-up on the visit with photos or notes taken there, more creative work, the extended possibilities on site, for example through apps, or the opportunity to work on questions more flexibly and at short notice.

The interviewees did not mention aspects such as new interaction and participation value of the learning place (Brill and Flügel, 2022) or new possibilities through interactive teaching pathways (e.g. Actionbound) (Fränkel et al., 2020; Hermes and Kuckuck, 2016). Here too, it should be investigated further why the prospective teachers only occasionally emphasize practical use. Perhaps they still lack the relevant experience or imagination here.

Out-of-school learning places and digital media are generally very popular with teachers and have many advantages (Degner et al., 2022; Mitzlaff, 2020; Wenzel and Blumberg a, b), but the combination does not seem to have any additional advantages from their point of view.

However, some disadvantages are named in connection with the combination. The disadvantages of digital media at the out-of-school learning place mentioned relate to the technical requirements, such as Wi-Fi or electricity for the devices, taking them to the out-of-school learning place and handling them, as well as the limited knowledge. In addition to the specific disadvantages, general disadvantages of digital media such as distractions, media time or lack of equipment can also be transferred (Wenzel and Blumberg, submitted b).

The biggest specific disadvantage mentioned is the technical conditions at the out-of-school learning place. This can be very different, especially if the teacher organizes the visit to the out-of-school learning place themselves, e.g., in the forest. Therefore, the development and expansion of the digital infrastructure (DigitalPakt Schule) in Germany is important (Wohlfart and Wagner, 2022). Appropriate training or cooperation with partners could also be helpful.

Moreover, there is research on out-of-school learning visits being only sustainable when preparation and follow-up are done at school (Itzek-Greulich and Vollmer, 2017; Reimann et al., 2020). It is most likely similarly true for use of digital media. Hence, if students are used to using their digital devices at school, and then bring them to the out-of-school learning places, it's nothing new and could be more easily integrated as a tool, rather than being an extra happening or cognitive load.

It can be concluded from this that the interview participants would not likely combine out-of-school learning and digital media. Although it is important, because the competent use of digital media is a development process and thus a central task of lifelong learning. This should already be trained with younger children in a diverse setting (Süss et al., 2018). And since the research field is still quite new, it can be important to research as broadly as possible to get comprehensive results (Degner et al., 2022; Mohajan, 2018). The small sample size of 20 students could be seen as a limitation of the study. However, there was already a saturation of findings here. Nonetheless, some of the results are rather general and therefore superficial. Therefore, some aspects should be analyzed more closely in the following to obtain more detailed results (see above and Outlook). This overview article provides a good basis for this.

CONCLUSION AND OUTLOOK

Overall, the prospective teachers have a positive attitude toward digital media in science lessons, although they are rather critical of the use of digital media in out-of-school learning places. It would therefore be helpful to interview currently practicing science teachers to be able to analyze further experiences and hurdles from practice.

In addition, the topic should be integrated into university education. For this reason, consideration should be given to making this compulsory in teacher training programs. Digital media in particular are already being taken into account in courses at many universities. However, this does not yet seem to be sufficient. Educational policy would also have to provide more resources for this. The connection between the two topics still seems to have received little attention. This should include

more knowledge about both topics, get to know different possibilities of the connection, and create more concepts for the connection as good practice examples. One of the few examples would be the seminar "Promoting science learning through the implementation of digital media at out-of-school learning places" at the University of Paderborn (Wenzel et al., 2024), which could serve as a model. It should also be checked whether the combination of both topics is useful and which conditions for success must be fulfilled for a linkage to prove useful. Moreover, it could be interesting to ask the students about their opinions.

ETHICS STATEMENT

According to the ethics committee of the University of Paderborn, the study is ethically unobjectionable (No. 62/2023).

DISCLOSURE STATEMENT

The authors report there are no competing interests to declare.

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REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179-211.

Andraschke, U., & Wagner, S. (Eds.). (2020). *Objekte im Netz: Wissenschaftliche Sammlungen im Digitalen Wandel* [*Objects on the Net. Scientific Collections in the Digital Transformation*]. Vol. 33. Bielefeld: Transcript Verlag.

Aufenanger, S. (2017). Zum stand der forschung zum tableteinsatz in schule und unterricht aus nationaler und internationaler sicht [The state of research on the use of tablets in schools and lessons from a national and international perspective]. In: Bastian, J., & Aufenanger, S. (Eds.), *Tablets in Schule und Unterricht: Forschungsmethoden und-Perspektiven zum Einsatz Digitaler Medien.* Wiesbaden: Springer Fachmedien, pp. 119-138.

Baar, R., & Schönknecht, G. (2018). *Außerschulische Lernorte: Didaktische und Methodische Grundlagen* [*Out-of-school Places of Learning: Didactic and Methodological Principles*]. Reutlingen: Beltz.

Berg, T.B., Achiam, M., Poulsen, K.M., Sanderhoff, L.B., & Tøttrup, A.P. (2021). The role and value of out-of-school environments in science education for 21st century skills. *Frontiers in Education*, 6, 674541.

Bernath, J., Waller, G., & Meidert, U. (2020). *ADELE+. Der Medienumgang von Kindern im Vorschulalter (4-6 Jahre). Chancen und Risiken für die Gesundheit [ADELE+. Media use by Children of Pre-school age (4-6 Years). Opportunities and Risks for Health]. Schweizerisches Gesundheitsobservatorium*. Available from: https://www.zhaw.ch/storage/psychologie/upload/forschung/medienpsychologie/adele/OBSAN_ADELE_Bericht_10-2020.pdf [Last accessed on 2024 Dec 15].

Bertelsmann Stiftung. (Ed.). (2015). *Individuell Fördern Mit Digitalen Medien: Chancen Risiken Erfolgsfaktoren* [*Individual Support with Digital Media. Opportunities Risks Success Factors*]. Germany: Verlag Bertelsmann Stiftung.

Blaseio, B. (2016). Ausserschulische lernorte im sachunterricht: vielperspektivisches sachlernen vor Ort [Out-of-school places of learning in nature and social science for elementary education. multi-perspective subject learning on site]. In: Erhorn, J., & Schwier, J. (Eds.), *Pädagogik. Pädagogik Außerschulischer Lernorte: Eine Interdisziplinäre Annäherung*. Germany: Transcript Verlag, pp. 261-282.

Brill, S., & Flügel, A. (2022). Digital unterwegs-außerschulische lernorte im kontext digitaler praktiken [Digital on the move-out-of-school learning places in the context of digital practices]. In: *Sachunterricht in der Informationsgesellschaft*. Bad Heilbrunn: Verlag Julius Klinkhardt, pp. 73-80.

Budde, J., & Hummrich, M. (2016). Die Bedeutung Außerschulischer Lernorte im Kontext der Schule-Eine Erziehungswissenschaftliche Perspektive [The Importance of Out-of-school Places of Learning in the Context of School-An Pedagogical Perspective]. In: Erhorn, J., & Schwier, J. (Eds.), *Pädagogik. Pädagogik Außerschulischer Lernorte: Eine Interdisziplinäre Annäherung*. Bielefeld: Transcript Verlag. pp. 29-52.

Büssing, A.G. (2021). Nachhaltigkeit in virtual reality erfahrbar machen: Immersive naturerlebnisse mit 360-grad-videos [Making sustainability tangible in virtual reality: Immersive nature experiences with 360-degree videos]. *Der Mathematische Und Naturwissenschaftliche Unterricht*, 74(5), 375-380.

Caruso, C., Müller, K., Schössow, M., & Wagener, M. (2020). Entwicklung Digitaler Lernangebote für Außerschulische Lernorte [Development of Digital Learning Opportunities for Out-of-school Learning Places]. In: Beyer, L., Gorr, C., Kather, C., Komorek, M., Röben, P., & Selle, S. (Eds.), *Außerschulische Lernorte-Beiträge zur Didaktik: Band 6. Orte und Prozesse außerschulischen Lernens Erforschen und Weiterentwickeln: Tagungsband zur 6. Tagung Außerschulische Lernorte an der Carl von Ossietzky Universität Oldenburg Vom 29-31. August 2018.* LIT, pp. 183-194.

Dannwolf, L., Matusch, T., Keller, J., Redlich, R., & Siegmund, A. (2020). Bringing earth observation to classrooms-the importance of out-of-school learning places and E-Learning. *Remote Sensing*, 12(19), 3117.

Degner, M., Moser, S., & Lewalter, D. (2022). Digital media in institutional informal learning places: A systematic literature review. *Computers and Education Open*, 3(1), 100068.

Deinet, U., & Derecik, A. (2016). Die Bedeutung außerschulischer Lernorte für Kinder und Jugendliche: Eine raumtheoretische und aneignungsorientierte Betrachtungsweise [The importance of out-of-school places of learning for children and young people. A space-theoretical and appropriation-orientated approach]. In: Erhorn, J., & Schwier, J. (Eds.), *Pädagogik. Pädagogik Außerschulischer Lernorte: Eine Interdisziplinäre Annäherung*. Bielefeld: Transcript Verlag, pp. 15-28.

Döring, N., & Bortz, J. (2016). *Forschungsmethoden und Evaluation in den Sozial-und Humanwissenschaften* [*Research Methods and Evaluation in the Social and Human Sciences*]. 5th ed. New York: Springer-Lehrbuch, Springer.

Dorouka, P., & Kalogiannakis, M. (2024). Teaching nanotechnology concepts in early-primary education: An experimental study using digital games. *International Journal of Science Education*, 46(13), 1311-1338.

Dühlmeier, B. (2022a). Einleitung [Introduction]. In: Dühlmeier, B. (Ed.), *Mehr Außerschulische Lernorte in der Grundschule: Neun Beispiele für den Fachübergreifenden Sachunterricht*. 4th ed. Germany: Schneider Verlag Hohengehren GmbH, pp. 3-5.

Dühlmeier, B. (2022b). Grundlagen Außerschulischen Lernens [Basics of Out-of-School Learning]. In: Dühlmeier, B. (Ed.), *Mehr Außerschulische Lernorte in der Grundschule: Neun Beispiele für den Fachübergreifenden Sachunterricht*. 4th ed. Germany. Schneider Verlag Hohengehren GmbH, pp. 6-50.

Eckes, A., Moormann, A., & Büssing, A.G. (2021). Natur 2.0-Erlebnisse in immersiver virtueller realität als möglichkeit für naturerfahrungen? [Nature 2.0-Experiences in immersive virtual reality as a way of experiencing nature?]. In: Gebhard, U., Lude, A., Möller, A., & Moormann, A. (Eds.), *Naturerfahrung und Bildung*. Berlin: Springer, pp. 361-377.

Fränkel, S., Sellmann-Risse, D., & Grotjohann, N. (2020). Digitale Schnitzeljagd im Wald [Digital Scavenger Hunt in the Forest]. In: *Herausforderung Lehrer*Innenbildung-Zeitschrift zur Konzeption, Gestaltung und Diskussion*. Vol. 3, pp. 34-47.

Glüer, M. (2021). Digitale medienkompetenzen und cyberbullying [digital media skills and cyberbullying]. In: Lohaus, A., & Domsch, H. (Eds.), *Psychotherapie: Praxis Ser. Psychologische Förder-und Interventionsprogramme Für das Kindes-und Jugendalter*. 2nd ed. Heidelberg: Springer Berlin, pp. 275-286.

Habermann, K. (2021). Verwendung Digitaler Medien in der Schule [Use of digital media at school]. In: Habermann, K. (Ed.), *Moremedia. Eltern-*

Guide Social Media: Instagram Snapchat TikTok und Co.-Kinder und Jugendliche unterwegs im Internet. Berlin: Springer, pp. 41-63.

Hahn, H.P. (2020). Das digitalisierte museum-erweiterung oder transformation? zur selbstpositionierung von museen im 21. Jahrhundert [The digitalised museum-expansion or transformation? On the self-positioning of museums in the 21st Century]. In: Andraschke, U., & Wagner, S. (Eds.), *Objekte im Netz: Wissenschaftliche Sammlungen im Digitalen Wandel*. Germany: Transcript Verlag, pp. 45-60.

Hermes, A., & Kuckuck, M. (2016). *Digitale Lehrpfade Selbstständig Entwickeln-Die App Actionbound als Medium für den Geographieunterricht zur Erkundung außerschulische Lernorte* [*Developing Digital Educational Trails Independently-The Actionbound App as a Medium for Geography Lessons to Explore Non-School Learning Places*]. Washington, DC: GW-Unterricht, pp. 174-182.

Herzig, B. (2020). Medienbildung in der Grundschule-Ein Konzeptioneller Beitrag zur Auseinandersetzung mit (digitalen) Medien [Media Education in Primary Schools-A Conceptual Contribution to Dealing with (Digital) Media]. *Zeitschrift Für Grundschulforschung*, 13(1), 99-116.

Hillmayr, D., Reinhold, F., Ziernwald, L., & Reiss, K. (2017). *Digitale Medien im Mathematisch-naturwissenschaftlichen Unterricht der Sekundarstufe: Einsatzmöglichkeiten, Umsetzung und Wirksamkeit* [*Digital Media in Maths and Science Lessons at Secondary Level. Possible Applications, Implementation and Effectiveness*]. Waxmann-E-Books Didaktik, Schule und Unterricht. Waxmann. Available from: https://elibrary.utb.de/doi/book/10.31244/9783830987666 [Last accessed on 2024 Dec 15].

Horn, M.S., Phillips, B.C., Evans, E.M., Block, F., Diamond, J., & Shen, C. (2016). Visualizing biological data in museums: Visitor learning with an interactive tree of life exhibit. *Journal of Research in Science Teaching*, 53(6), 895-918.

Hussy, W., Schreier, M., & Echterhoff, G. (2013). *Forschungsmethoden in Psychologie und Sozialwissenschaften für Bachelor* [*Research Methods in Psychology and Social Sciences for Bachelor Students*]. 2nd ed. Germany: Springer-Lehrbuch, Springer.

Irion, T. (2018). Wozu Digitale Medien in der Grundschule? Sollte das Thema Digitalisierung in der Grundschule Tabuisiert Werden? [Why Digital Media in Primary School? Should the Topic of Digitalisation be Taboo in Primary Schools?]. In: *Grundschule Aktuell: Zeitschrift des Grundschulverbandes*. Vol. 142, pp. 3-7.

Itzek-Greulich, H., & Vollmer, C. (2017). Emotional and motivational outcomes of lab work in the secondary intermediate track: The contribution of a science center outreach lab. *Journal of Research in Science Teaching*, 54(1), 3-28.

Jäkel, L. (Ed). (2021). Lernort museum [Museum as a place of learning]. In: *Faszination der Vielfalt des Lebendigen-Didaktik des Draußen-Lernens*. Berlin Heidelberg: Springer, pp. 263-275.

Kampschulte, L. (2018). Lernorte mit Medien vernetzen. Chancen und Herausforderungen der lernortübergreifenden Mediennutzung. In: Ropohl, M., Lindmeier, A., Härting, H., Kampschulte, L., Mühling, A., & Schwanewedel, J. (Eds.), *Medieneinsatz im Mathematisch-naturwissenschaftlichen Unterricht. Fachübergreifende Perspektiven auf zentrale Fragestellungen*. Hamburg: Joachim Herz Stiftung, pp. 138-174.

Kampschulte, L., Müller, F., Ostermann, A., Ropohl, M., Schwanewedel, J., Härting, H., & Lindmeier, A. (2019). Einsatz digitaler und analoger Medien an außerschulischen Lernorten [Use of digital and analogue media at out-of-school learning places]. In: *Proceedings of the IPN-Leibniz-Institut für die Pädagogik der Naturwissenschaften und Mathematik.* Available from: https://scholar.google.com/citations?user=iqjcqocaaaaj&hl=de&oi=sra [Last accessed on 2024 Dec 15].

Karpa, D., Lübbeke, G., & Adam, B. (Eds.). (2015). Zur einführung [introduction]. In: *Reihe: Band 31. Außerschulische Lernorte: Theorie, Praxis und Erforschung Außerschulischer Lerngelegenheiten*. France: Prolog Verlag, pp. 7-9.

Kersken, S. (2023). *IT-Handbuch für Fachinformatiker*innen: Der Ausbildungsbegleiter* [*IT Handbook for IT Specialists*]. 11th ed. Germany: Rheinwerk Verlag. Available from: https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=7267046 [Last accessed on 2024 Dec 15].

Kramer, K., & Gabler, S. (2022). Medienkompetenzentwicklung im Lehramtsstudium am Beispiel der WiPra1-Lehre für Lehramtsstudierende: Medienkompetenz Praxisnah [Developing media skills in teacher training programmes using the example of the WiPra1 course for student teachers: Media skills in practice]. In: Kramer, K., & Hoyer, B. (Eds.), *"Indivieduell Fördern"-Wissenschaftlicher Hintergrund Sowie Ansatzpunkte aus und für die Praxis*. Boca Raton: FAU University Press, pp. 231-254.

Kuckartz, U. (2016). *Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung* [*Qualitative Content Analysis. Methods, Practice, Computer Support*]. 3rd ed. Beltz: Grundlagentexte Methoden.

Kuckartz, U., & Rädiker, S. (2022). *Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung: Grundlagentexte Methoden* [*Qualitative Content Analysis. Methods, Practice, Computer Support: Basic Texts Methods*]. 5th ed. Beltz Juventa: Grundlagentexte Methoden. Available from: https://permalink.obvsg.at/AC16378905 [Last accessed on 2024 Dec 15].

Kunkel, C., & Peschel, M. (2020). Lernen Mit und über Digitale Medien im Sachunterricht [Learning with and about digital media in nature and social science for elementary education]. *MedienPädagogik: Zeitschrift Für Theorie Und Praxis Der Medienbildung*, 17, 455-476.

Kuske-Janßen, W., Niethammer, M., Pospiech, G., Wieser, D., Wils, J.T., & Wilsdorf, R. (2020). Außerschulische Lernorte-theoretische Grundlagen und Forschungsstand [Out-of-School Places of Learning-Theoretical Foundations and State of Research]. In: Pospiech, G., Niethammer, M., Wieser, D., & Kuhlemann, F.M. (Eds.), *Begegnungen mit der Wirklichkeit (E-Book): Chancen für Fächerübergreifendes Lernen an Außerschulischen Lernorten*. 1st ed. Güglingen: Hep Verlag, pp. 21-49.

Lakin, L. (2006). Science beyond the Classroom. *Journal of Biological Education*, 40(2), 89-90.

Landis, J.R., & Koch, G.G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159-174.

Lin, P.Y., & Schunn, C.D. (2016). The dimensions and impact of informal science learning experiences on middle schoolers' attitudes and abilities in science. *International Journal of Science Education*, 38(17), 2551-2572.

Mantiri, F. (2014). Multimedia and technology in learning. *Universal Journal of Educational Research*, 2(9), 589-592.

Mayer, R.E. (2014). Cognitive theory of multimedia learning. In: Mayer, R.E. (Ed.), *The Cambridge Handbook of Multimedia Learning*. Cambridge University Press, pp. 43-471.

Mayer, R.E. (2021). *Multimedia Learning*. 3rd ed. Cambridge: Cambridge University Press.

Medienberatung, N.R.W. (2020). *Medienkompetenzrahmen NRW* [*Media Competence Framework NRW*]. Available from: https://medienkompetenzrahmen.nrw/fileadmin/pdf/LVR_ZMB_MKR_Rahmen_A4_2020_03_Final.pdf

Medienpädagogischer Forschungsverbund Südwest. (2022a). *JIM-Studie 2022: Jugend, Information Medien Basisuntersuchung zum Medienumgang 12- bis 19-Jähriger* [*JIM Study 2022: Youth, Information Media Basic study on the media Consumption of 12 to 19-year-olds*]. Available from: https://mpfs.de/app/uploads/2022/10/JIM_2022_Web_final.pdf [Last accessed on 2024 Dec 15].

Medienpädagogischer Forschungsverbund Südwest. (2022b). *KIM-Studie 2022: Kindheit, Internet, Medien - Basisuntersuchung zum Medienumgang 6- bis 13-Jähriger* [*KIM Study 2022: Childhood, Internet, Media-Basic Study on the Media Behaviour of 6 to 13-Year-Olds*]. Available from: https://mpfs.de/app/uploads/2024/11/KIM-Studie2022_website_final.pdf [Last accessed on 2024 Dec 15].

Meyer, F. (2018). Yes, we can(?) Kommunikative Validierung in der qualitativen Forschung [Yes, we can(?) Communicative validation in qualitative research]. In: Meyer, F., Miggelbrink, J., & Beurskens, K. (Eds.), *Ins Feld und zurück-Praktische Probleme qualitativer Forschung in der Sozialgeographie.* Berlin: Springer Spektrum, pp. 163-168.

Mitzlaff, H. (2020). Exkursionen im Sachunterricht-Der Königsweg zu den "Sachen"? [Excursions in Nature and Social Science lessons-the ideal way to 'things'?]. In: Kaiser, A., & Pech, D. (Eds.), *Basiswissen Sachunterricht.* Vol. 5. 7th ed. France: Unterrichtsplanung und Methoden, pp. 136-144.

Mohajan, H.K. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of Economic Development, Environment and People*, 7(1), 23-48.

Nelson, B.C., Bowman, C.D.D., Bowman, J.D., Pérez Cortés, L.E.,

Adkins, A., Escalante, E., Owen, B.L., Ha, J., & Su, M. (2020). Ask Dr. Discovery: The impact of a casual mobile game on visitor engagement with science museum content. *Educational Technology Research and Development*, 68(1), 345-362.

Neumann, M.M. & Neumann, D.L. (2014). Touch screen tablets and emergent literacy. *Early Childhood Education Journal*, 42(4), 231-239.

Ofcom. (Ed.). (2021). *Children and Parents: Media use and Attitudes Report 2020/21*. Available from: https://www.ofcom.org.uk/research-and-data/media-literacy-research/childrens/children-and-parents-media-use-and-attitudes-report-2021 [Last accessed on 2024 Dec 15].

Ofcom. (Ed.). (2023a). *Adults' Media Use and Attitudes Report 2023*. Available from: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/255844/adults-media-use-and-attitudes-report-2023.pdf [Last accessed on 2024 Dec 15].

Ofcom. (Ed.). (2023b). *Media Nations UK 2023*. Available from: https://www.ofcom.org.uk/research-and-data/tv-radio-and-on-demand/media-nations-reports/media-nations-2023 [Last accessed on 2024 Dec 15].

Pallack, A. (2018). *Digitale Medien im Mathematikunterricht der Sekundarstufen I+II [Digital Media in Maths Lessons at Secondary Levels I+II*]. Berlin: Springer.

Petko, D. (2020). *Einführung in die Mediendidaktik: Lehren und Lernen mit Digitalen Medien* [*Introduction to Media Didactics. Teaching and Learning with Digital Media*]. 2th ed. Bangalore: Beltz.

Potter, W.J. (2018). *Media Literacy*. Washington, DC: SAGE Publications.

Reichwein, W. (Ed.). (2021). *Unterricht Digital Gestalten.: Rahmenbedingungen und Beispiele für Digitales Lernen mit iPads. Eine Zusammenstellung von Ergebnissen aus dem Projekt "Digitales Lernen mit Tablets" an der Universität Hamburg* [*Designing Lessons Digitally. Framework Conditions and examples of Digital Learning with iPads. A Compilation of Results from the Project 'Digital Learning with Tablets' at the University of Hamburg*]. Berlin: Neopubli GmbH.

Reimann, M., Herzog, S., Parchmann, I., & Schwarzer, S. (2020). Wirksamkeit der schulischen vor- und nachbereitung eines schülerlaborbesuches [Effectiveness of school-based preparation and follow-up of a school lab visit]. *Zeitschrift für Didaktik der Naturwissenschaften*, 26(1), 227-240.

Rideout, V., & Robb, M.B. (2020). *He Common Sense Census: Media use by Kids Age Zero to Eight*. Common Sense Media. Available from: https://www.commonsensemedia.org/sites/default/files/research/report/2020_zero_to_eight_census_final_web.pdf [Last accessed on 2024 Dec 15].

Sauerborn, P., & Brühne, T. (2020). *Didaktik des Außerschulischen Lernens* [*Didactics of out-of-school Learning*]. 7th ed. Schneider Verlag Hohengehren GmbH. Available from: https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=6914424 [Last accessed on 2024 Dec 15].

Schmeinck, D. (2022). Digitalisierung im sachunterricht der grundschule-bildungspolitischer rahmen und notwendige digitalbezogenen kompetenzen von schülerinnen und schülern [Digitalisation in primary school Nature and Social Science lessons-educational policy framework and necessary digital skills for schoolchildren]. In: Haider, M., & Schmeinck, D. (Eds.), *Digitalisierung in der Grundschule. Grundlagen, Gelingensbedingungen und Didaktische Konzeptionen am Beispiel des Fach Sachunterrichts*. Bad Heilbrunn: Verlag Julius Klinkhardt, pp. 27-40.

Schmid, U., Goertz, L., & Behrens, J. (2017). *Monitor Digitale Bildung: Die Schulen im Digitalen Zeitalter* [*Digital Education Monitor: Schools in the Digital Age*]. Germany: Bertelsmann Stiftung.

Schwan, S., Grajal, A., & Lewalter, D. (2014). Understanding and engagement in places of science experience: Science museums, science centers, zoos, and aquariums. *Educational Psychologist*, 49(2), 70-85.

Shibata, H., & Omura, K. (2018). [Papers] reconsideration of the effects of handwriting. *ITE Transactions on Media Technology and Applications*, 6(4), 255-261.

Steinke, I. (2007). Die Güte qualitativer marktforschung [The quality of qualitative research]. In: Buber, R., & Holzmüller, H.H. (Eds.), *Qualitative Marktforschung*. Germany: Gabler, pp. 261-283.

Süss, D., Lampert, C., & Trültzsch-Wijnen, C.W. (2018). *Medienpädagogik: Ein Studienbuch zur Einführung* [*Media Education. A Study Book for Introduction*]. Offenburg: VS Verlag für Sozialwissenschaften.

Thomas, B. (2009). Lernorte Außerhalb der Schule [Places of Learning Outside the School.]. In: Arnold, K.H., Sandfuchs, U., & Wiechmann, J. (Eds.), *Handbuch Unterricht*. 2nd ed. Belgium: UTB GmbH, pp. 283-287.

Uludag, G. (2021). Views of preschool teachers on using out-of-school learning environments in preschool education. *International Online Journal of Education and Teaching*, 8(2), 1225-1249.

Vogelsang, C., Finger, A., Laumann, D., & Thyssen, C. (2019). Vorerfahrungen, einstellungen und motivationale orientierungen als mögliche einflussfaktoren auf den einsatz digitaler werkzeuge im naturwissenschaftlichen unterricht [Prior experience, attitudes and motivational orientations as possible influencing factors on the use of digital tools in science lessons]. *Zeitschrift Für Didaktik Der Naturwissenschaften*, 25(1), 115-129.

Wahl, M. (2021). Digitale medien in der unterstützten kommunikation [digital media in augmentative and alternative communication]. *Spektrum Patholinguistik*, 14(1), 55-67.

Waite, S. (2020). Where are we going? International views on purposes, practices and barriers in school-based outdoor learning. *Education Sciences*, 10(11), 311.

Wejner, M., & Wilke, T. (2022). LabPi: A digital measuring station for STEM education 4.0. *Journal of Chemical Education*, 99(2), 819-827.

Wenzel, A., & Blumberg, E. (Submitted A). Digital Media in Elementary School Science Lessons: An Interview Study with (Prospective) Science Teachers. In: *Contributions from Biology Education Research*. Heidelberg: Springer.

Wenzel, A., & Blumberg, E. (Submitted B). *Außerschulische Lernorte als Bestandteil des naturwissenschaftlichen Sachunterrichts-eine Interviewstudie mit angehenden Sachunterrichtslehrkräften* [*Out-of-school Learning Places as a Component of Science Lessons-an Interview study with Prospective Science Teachers*]. United States: Wiley

Wenzel, A., Schulze, J.R., Crummenerl, L.L., & Blumberg, E. (2024). Durch den Einsatz digitaler Medien an außerschulischen Lernorten naturwissenschaftliches Lernen fördern [Promoting science learning through the use of digital media at out-of-school learning places]. In: Herzig, B., Eickelmann, B., Schwalb, F., Schulze, J., & Niemann, J. (Eds.), *Lehrkräftebildung in der Digitalen Welt*. Germany: Waxmann Verlag GmbH.

Wilde, M., Retzlaff-Fürst, C., Scheersoi, A., Basten, M., & Groß, J. (2019). Non-formales biologielernen mit schulbezug [Non-formal biology learning with school reference]. In: Groß, J., Hammann, M., Schmiemann, P., & Zabel, J. (Eds.), *Biologiedidaktische Forschung Erträge für die Praxis*. Berlin: Springer Spektrum, pp. 251-268.

Wohlfart, O., & Wagner, I. (2022). "DigitalPakt Schule 2019 bis 2024"-Analyse der strukturellen Digitalisierung des Bildungssystems in Deutschland ['DigitalPakt Schule 2019 to 2024'-Analysis of the Structural Digitalisation of the Education System in Germany]. *Praxis Forschung Lehrer*innen Bildung. Zeitschrift für Schul- und Professionsentwicklung*, 4(1), 202-213.

Yildirim, H.I. (2018). The impact of out-of-school learning environments on 6th grade secondary school students attitude towards science course. *Journal of Education and Training Studies*, 6(12), 26.

Yoon, S.A., & Wang, J. (2014). Making the invisible visible in science museums through augmented reality devices. *TechTrends*, 58(1), 49-55.

YouGov. (2022). Global Media Outlook Report 2022. Available from: https://business.yougov.com/sectors/media-content/global-media-outlook-report-2022 [Last accessed on 2024 Dec 15].