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Digital sovereignty of physical education teachers in Germany: a situation analysis (2017–2021) on the gap between educational policies and practical implementation in further physical education teacher trainings

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The increasing digitalization of society, particularly in education, requires both institutions and individuals to develop necessary structures and competencies for a confident participation in the digital world, a concept defined as digital sovereignty. Physical education (PE) teachers' digital literacy is crucial to address the challenges of digitalization and this is to be developed with further PE teacher trainings. Therefore, this study investigates the integration of content on digitalization in further PE teacher trainings across Germany between January 2017 and May 2021. To address the question how digitalization-related content is represented in the further PE teacher trainings, a total dataset of 6,326 further PE teacher trainings involving 48,540 teachers was analyzed. The SEPAC.digital model was used as the theoretical framework in order to underpin PE-related issues from a perspective of content knowledge and to position the digital world as a global media phenomenon. The analysis shows a wide variation in representative digitalization-related content available in the German federal states. Further qualitative content analysis categorized the content in three stages into content with or without reference to digitalization, digitalization-related aspects and movement fields. The systematic and category-based approach allows for the content of further PE teacher trainings to be systematized and conclusions to be drawn to answer the research questions. Four of 12 German federal states did not offer any digitalization-related further teacher trainings at all, while the others offered further PE teacher trainings on digitalization with a share of 0.6 to 4.6. This reveals that most digitalization-related content focused on the functional use of media, such as video analysis. Only little emphasis is placed on the development of digital competencies or the personal-reflective dimension of digitalization. As a result, the study identifies the limited inclusion of digital content in further PE teacher trainings and following insufficient digital competencies among PE teachers. This result can be further emphasized by considering the significant disparity among the German federal states. Additionally, the study identifies a significant gap between the objectives of federal educational policies and the actual implementation of digital education in further PE teacher trainings. The findings

suggest that further PE teacher trainings are largely inadequate in addressing the transformative potential of digitalization. Further teacher training is crucial for developing digital competencies among PE teachers and aligning their skillset with the demands of students' increasingly digitalized life. Recommendations are consequently made for developing more targeted and comprehensive further PE teacher trainings, emphasizing both the practical and the critical reflection of digital media in PE. The study thereby contributes to the academic discourse by highlighting the necessary link between policy initiatives and subject-specific approaches to digital competencies in PE to develop evidence-based further PE teacher trainings.

KEYWORDS

physical education, further physical education teacher training, digital sovereignty, digital competencies, digital transformation

1 Introduction

A mere 25.9% of German respondents reported having received training on integrating digital technologies into their teaching practice. This places Germany significantly lower than both the European (32.8%) and the international (47.5%) average (Eickelmann et al., 2018). The fact highlights the contrast given that the extensive and continuous digitalization of our everyday life has a widespread impact on society, particularly in the educational sector – often referred as digital transformation (McCarthy et al., 2020). To be able to act independently, self-determined, and confident in the digital world, institutions and individuals need to develop abilities that lead to successful participation in and within the digital world and thus contribute to digital sovereignty (Goldacker, 2017). The discussion about digital sovereignty can be applied to a state or supranational institutions, organizations or companies, and individuals (Fries et al., 2022). Therefore, using digital technologies in education aims to promote higher learning outcomes and improve quality of teaching which require pedagogically justified and meaningful use of information and communication technologies (ICT) (Instefjord and Munthe, 2017). Using ICT is a “necessary condition for promoting effective teaching and preparing students for the future” (Karaiskos et al., 2024, p. 2029). Although this use is justified from a pedagogical point of view, it also represents a major challenge for teachers, who must possess the necessary competencies for digitalization in an educational context (Pettersson, 2018). In the literature, concepts such as digital literacy and media literacy are named and used, which are closely related to digital competencies (Erstad and Amdam, 2013). In order to acquire and promote digital competencies in the long term, subject-specific teacher training is necessary (Lipowsky and Rzejak, 2021). This is mandatory in several European states (Tannehill et al., 2021) and across all subjects in Germany. Beyond the European context, further teacher training has likewise become a major priority in education system Banks and Smyth (2011). The German federal government has launched various initiatives (including funding for research projects) to enhance the further development of digitization in the educational context. However, there is still an urgent need for action, particularly in the third phase of teacher training programs. According to Greve et al. (2020), digitalization in PE can contribute to learning with and through digital media. In particular, digital media can be used to organize lessons and improve classroom management. Therefore, this article aims to explore the extent to which the increase

in digitalization has impacted the thematic focus of further teacher training – especially in physical education (PE), which has specific teaching conditions (i.e., lessons in sports halls, on sports fields, in the swimming pool).

2 State of research

2.1 Educational policy perspective on digital sovereignty

In Germany, teacher training can be basically categorized into three phases. After completion of their studies, prospective teachers engage in a period of professional development, known as internship, which prepares them for their future roles. Throughout their professional careers and as the third phase of teacher training, teachers participate in further teacher trainings to enhance their qualifications (Kultusministerkonferenz (KMK), 2022). To address the subject of further teacher training as the main part of the third phase in teacher training, it is necessary to define digital sovereignty as the objective and to classify media literacy as a requirement for digital sovereignty from an educational policy perspective (Blossfeld, 2018). According to Friedrichsen and Bisa (2016) digital sovereignty is the self-determined handling of digitalization (which is a process of a system) and digitality (which is a state of a system), as well as successful participation in and within the digital world. This requires the acquisition of specific digital and IT skills to be able to use digital media in an independent manner and adapt to the digital world's constantly changing demands [Blossfeld, 2018; Kultusministerkonferenz (KMK), 2021]. Skills like using new technologies, social skills, and digital competencies can be summarized under the widely used term of digital literacy (Purina-Bieze, 2021). In this paper, the construct of digital literacy is used according to Klafki (Beck et al., 2015), i.e., as the requirement to act in a digitally sovereign way with self- and co-determination and solidarity. The construct of media literacy is used synonymously in this context (Erstad and Amdam, 2013). The Commission of European Communities defines “media literacy as the ability to assess the media, to understand and to critically evaluate different aspects of the media” and their content as well as to use ICT in various contexts (Commission of the European Communities, 2007, p. 3). This definition serves as the basis for the ongoing educational policy debate

on digitalization in Germany [Bundesministerium für Bildung und Forschung (BMBF), 2016; Kultusministerkonferenz (KMK), 2016, 2021; Ständige wissenschaftliche Kommission der Kultusministerkonferenz (SWK), 2021]. In Germany's federalist structure, all 16 federal states are responsible for education policies in their territory. In addition, each state is responsible for digital-related content in their curricula and for providing further information on this topic (Medienberatung, 2020). Thus, all 16 states have constitutional authority to develop and implement their education policies. Consequently, each federal state has autonomy in determining its curricula and the core curriculum of PE for the different German school levels such as primary school, secondary level I and II, special needs schools and vocational schools. This includes the acquisition of process- and content-related skills as well as the content arrangement of the movement fields [Kultusministerkonferenz (KMK), 2016]. In addition, each federal state is responsible for pedagogic employees' professionalization and thus, the teaching of digital competencies, which may only be realized as a part of further teacher training in the third phase across all federal states (Lipowsky and Rzejak, 2021). In order to support the federal states in the digital education of teachers, the Federal Republic of Germany tries to create structural opportunities: The 'DigitalPakt Schule' program is a measure that provides 6.5 billion euros to federal states and municipalities to expand digital infrastructure from 2019 to 2024 [Ständige wissenschaftliche Kommission der Kultusministerkonferenz (SWK), 2021]. According to the Federal Government's statement the funding will be continued with the 'DigitalPakt 2.0' program from 2024 to 2030 [Bundesministerium für Bildung und Forschung (BMBF), 2024]. Furthermore, the individual federal states have committed to provide digital education [Bundesministerium für Bildung und Forschung (BMBF), 2016]. This includes technical and organizational framework conditions, as well as teaching and training formats to develop digital literacy [Kultusministerkonferenz (KMK), 2021]. However, it remains unclear to what extent the federal states use the funds to finance one central strategy for training teachers in digitalization.

2.2 Theoretical modeling to emphasize the empirical educational basis

In addition to considering the educational policy perspective, it is important to take into account empirical educational research. Mishra and Koehler (2006) developed the TPACK model, which introduces 'Technological Knowledge' to form 'Technological Pedagogical Content Knowledge' (TPACK), highlighting the interconnected nature of its components (Thompson and Mishra, 2008). For a deeper understanding, refer to the foundational article by Mishra and Koehler (2006). The TPACK model serves as an empirical baseline but is not used for theoretical modeling because it lacks a personal-reflective dimension that is crucial for the development of digital sovereignty (Frederking, 2022a; Frederking, 2022b). Additionally, TPACK is far too general for use in research and simultaneously too specific for subject-didactic fields of knowledge (Wendeborn et al., 2022). However, Frederking (2022a), Frederking (2022b) proposes SEPAC.digital as an alternative model. SEPAC.digital uses the term 'Subject Educational Knowledge' (SEK), acknowledging the tradition of subject education as a distinct discipline in Germany and establishing a connection to subject-specific knowledge (Figure 1).

One notable aspect in SEPAC.digital is that the digital world is not considered a purely technological concept. Instead, the digital world is perceived as a global media phenomenon, impacting all aspects of life. It includes educational processes and forms an inherent framework. The model emphasizes the connection between the use of and the reflection on digital media: It encompasses, both, a reflective understanding of the functioning and societal consequences of the digital and allows for a reflective engagement with the phenomenon (Frederking, 2022b). The emphasis on the subject-specific and also subject-didactic perspective on digital education processes is closely linked to the discussion of digital literacy. A purely functional focus on the use of digital media neglects the personal-reflective dimension of subject-specific digital education. However, it is crucial for building

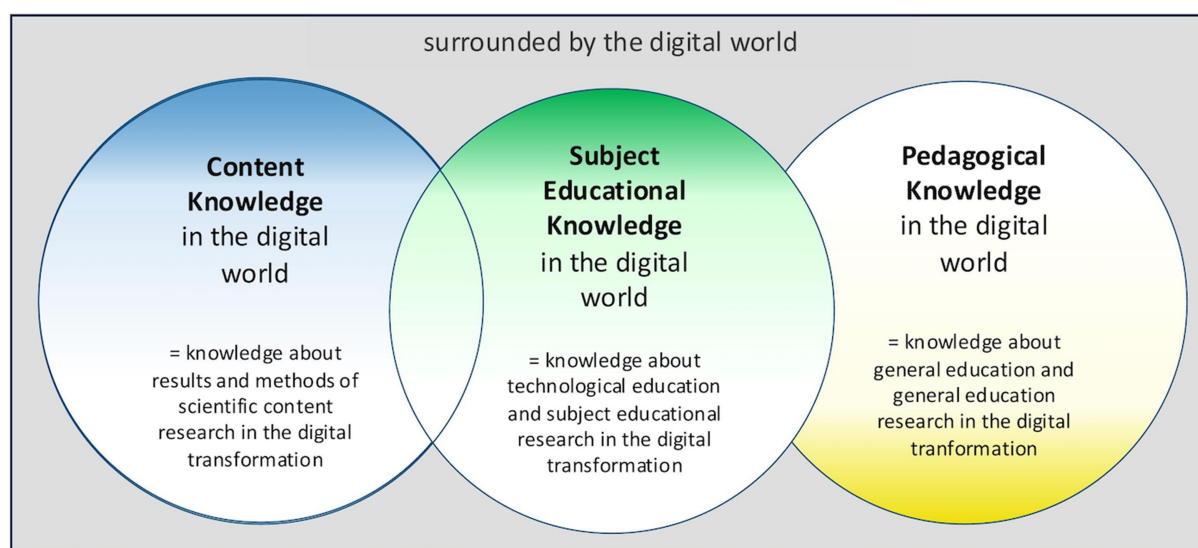


FIGURE 1

Adapted from Frederking (2022a), Frederking (2022b). SEPAC.digital - subject educational, pedagogical and content knowledge in the digital world.

digital literacy to have a stance toward oneself and toward the digital world.

2.3 Digital literacy

As previously mentioned, building digital literacy is crucial for navigating the digital world. It includes a set of appropriate skills for independent and critical use of digital media and ICTs and, thus, is the basis for teachers to prepare the next generation for the challenges of a digital world. These skills need to be developed during further teacher trainings. The demand for such opportunities can be underlined by the clear results of 'The International Computer and Information Literacy Study' (ICILS). Only 25.9% of the surveyed teachers had received training on the use of digital technologies and a similar percentage (26.6%) had the opportunity to learn how to integrate digital technologies into their lessons during teacher training. In international comparison, Germany falls in both cases significantly below the international average of 47.5 and 41.6%, respectively, in terms of digital skills acquisition (Eickelmann et al., 2018). In addition to the lack of digital competencies, an international comparative study revealed that German teachers have a low level of conviction regarding the effectiveness of digital media in promoting learning (Fraillon et al., 2019). This suggests that the framework conditions, such as further teacher training or its thematic design on digitalization-related content, are not sufficient to build corresponding competencies.

2.4 Digital literacy in PE

Due to the fact that this article focuses on digital literacy in PE the general and non-specific approach to digital literacy must be translated into the respective subject (Brueggemann and Frederking, 2024). For this subject-specific reference, Meier and Poweleit (2023) and Sagafe and Wendeborn (2023) provided the theoretical framework. For PE, this requires subject-specific differentiation with a functional and personal focus on digital sovereignty (Frederking, 2022b). The adaption of the general model to PE includes a survey on (1) the significance of digital media in PE (= harnessing the potential of technology), (2) the critical use of digital technologies and resources in PE (= information and media literacy) and (3) the acquisition of necessary competencies in PE (= security and responsibility). Although current research indicates that teachers' digital competencies are insufficient to meet the challenge of digitalization and PE teachers often see digitalization as a threat to their students, the use of digital technologies is crucial in the context of PE (Jastrow et al., 2022). PE is often taught in environments that are not technology-friendly, but PE is a unique subject in the traditional curriculum that focuses on the body as a medium and recipient of education, making human movement and physical activity its subject. Therefore, the integration of digital technologies, such as virtual reality simulations, can enhance students' motivation for physical activity (Koh et al., 2022). Otherwise, PE teachers can better manage subject-specific challenges and create a more positive teaching experience with enhanced digital competencies through targeted further teacher training (Karaiskos et al., 2024). Furthermore, scientific evidence supports that successful digital literacy requires an

integrated approach to developing digital and pedagogical competencies (Purina-Bieza, 2021). It is evident that teachers need to acquire digital competencies through training to successfully integrate digital technologies in PE. However, it is currently unclear to what extent further PE teacher training covers digitalization-related content.

2.5 Research questions

The theory section has highlighted the significance of digital literacy as a competence for PE teachers from both an educational policy and empirical perspective. However, there is still a research gap in understanding how the increasing digitalization has impacted further teacher training in the recent past. In Germany, a distinction can be made between the periods before and after the massive investment in digital infrastructures in schools [e.g., Ständige wissenschaftliche Kommission der Kultusministerkonferenz (SWK), 2021]. Furthermore, the time period selected for evaluation of teacher training is due to the fact that there are educational policy requirements to promote the offensive in the third phase of teacher training. The challenges in data collection are the reason for the long data collection period of 4.5 years. Nevertheless, this survey marks the beginning of regular surveys designed to facilitate continuous improvement of the supply of further teacher training. To address the research gap, the following research questions need to be answered:

- (1) How many further PE teacher trainings held during the specified period address digitalization-related content in general in relation to specific school levels (primary, secondary I and secondary II) in Germany? Due to other curricular conditions and the way in which physical education is embedded, special schools and vocational schools are not included. This question provides an overview of the general state of further PE teacher trainings in the selected and analyzed period.
- (2) With regard to the first question: Which aspects of digitalization are addressed in further PE teacher trainings that can be assigned a digitalization reference? The purpose of the first and second questions is to determine whether there is a deficit in further PE teacher trainings that justifies an evidence-based improvement of digitalization-related teacher training. Without specific competencies, teachers are not sufficiently empowered to include digitalization into subject educational teaching.

In consideration of the potential outcomes of the initial two questions, the following question focuses on the movement fields as a fundamental part of learning in PE.

- (3) What are the most frequently addressed movement fields of PE in further PE teacher trainings? This question aims to provide information about which core content of PE is most frequently represented in further PE teacher trainings held. By answering this question and in relation to the theoretical situation, it is possible to classify whether the movement fields are equally represented in further PE teacher trainings and how the correlation between the movement fields and digitalization is.

3 Research design

3.1 Data acquisition and collection

Data collection took place between July 2021 and February 2022 and included further PE teacher trainings that were conducted between January 2017 and May 2021. Due to the conducting time of four and a half years, a broad empirical basis is available, allowing conclusions to be drawn about possible development trends in further teacher training programs. All federal institutes of the 16 federal states in Germany were requested by the authors to submit information on the further PE teacher trainings they have conducted during the mentioned period. This request was made in written form via email, with follow-up telephone calls, and through independent research of the training portals. Three federal institutes did not respond to the inquiries so the data could not be included. The lack of these data could limit the representativeness of the following results and the transferability to the entire Federal Republic of Germany, particularly because one of the missing federal states is the most populous in Germany. Nevertheless, the collection of institutional data provides comprehensive insight into the implementation of education policy requirements for promoting digital literacy in PE. Additionally, the continuing education portals of the federal institutes were examined according to further PE teacher trainings held. The various types of educational institutions, which exist as a consequence of the federalism, were taken into account by categorizing them into corresponding types of schools. In addition, the different target groups of training courses were also recorded: PE teachers, PE students, newcomers and other pedagogical staff. To sum up, a total of 6,326 further PE teacher trainings were collected from 12 of 15 federal institutes (There is only one federal institute responsible for both states, Berlin and Brandenburg) with approximately 48,540 teachers at general education schools. The number of PE teacher trainings in the participating federal states differs significantly (between $n = 11$ and $n = 1,996$), depending on the size of the federal state and the number of teachers in the federal state. The number of teachers in the participating federal states varies considerably, from 7,095 to 121,699.

3.2 Data analysis

The survey was designed as a qualitative content analysis in three stages, based on the deductive-inductive formation of a category system which defines categories, provides anchor examples and establishes coding rules according to Mayring (2015). The chosen method of analysis which is divided in three stages, is directly linked to the three research questions. The SEPACK.digital model, as previously outlined, serves as a methodological basis for addressing PE-related issues from a perspective of content knowledge. In addition, SEPACK.digital can be used to address the subject-specific and personal-reflective perspective of school and teaching. Utilizing the methodology previously described the further PE teacher trainings were analyzed by three independent raters. The intercoder reliability was determined using the Fleiss-Kappa coefficient. Fleiss-Kappa varies from 0 to 1 and the correlation between Fleiss-Kappa and the intercoder agreement is shown in Table 1.

The assignment of further PE teacher trainings of movement field resulted in a Fleiss-Kappa coefficient of $\kappa = 0.80$. After sharpening the definitions, a Fleiss-Kappa coefficient of $\kappa = 0.86$ was obtained, which

TABLE 1 Fleiss-Kappa and intercoder agreement interpretation.

Fleiss-Kappa	Interpretation
<0.00	Poor agreement
0.00–0.20	Slight agreement
0.21–0.40	Fair agreement
0.41–0.60	Moderate agreement
0.61–0.80	Substantial agreement
0.81–1.00	Almost perfect

From Landis and Koch (1977).

from Table 1 signifies an almost perfect agreement between the raters. At the same time, the reference to digitalization in the further PE teacher trainings was also evaluated. This resulted in a substantial agreement value of $\kappa = 0.67$. The systematic and category-based approach allows for the content of further PE teacher trainings to be systematized and conclusions to be drawn, which in turn leads to answer the research questions.

In the initial stage and to answer the first research question, the content of all further PE teacher trainings was categorized into (1) further PE teacher training with reference to digitalization and (2) further PE teacher training without reference to digitalization. In a next step and to answer the second research question, the specific aspects of digitalization were examined by assigning the remaining digitalization-related further PE teacher trainings to different categories. A distinction was made between (1) the impact of social media, (2) the future of digital sport, (3) the possible use of digital media in PE, (4) the improvement of software skills (5) distance learning in sport and (6) video analysis to improve non-digital teaching skills.

In the following stage of qualitative content analysis and to address the third research question, the movement field of PE was analyzed and categorized into seven distinct areas with the addition of a further area to address further teacher trainings, which encompass more than one distinct. The analysis of movement fields is important since they form the core content of PE and, thus, also for further teacher trainings. The distinction is to be drawn between (1) games, (2) swimming, (3) gymnastics and movement arts, (4) gymnastics and dancing, (5) athletics, (6) moving on rolling and sliding equipment, (7) martial arts, (8) interdisciplinary, and (9) no assignment.

4 Results

4.1 Digitalization-related content

The table below shows the number of further PE teacher trainings held in 12 federal states of Germany. The sum represents the total number, while the relative number indicates the ratio between the total number of further PE teacher trainings and those related to digital content. The total dataset includes 6,326 further PE teacher trainings held in the mentioned period. The analysis to the first research question shows that events with digitalization-related content make up a very small proportion of the dataset (1.9%). This ratio already contains video analysis, which can be regarded as a topic with digital-related content in the broadest sense. A stricter rating without video analysis would reduce the ratio to 1.4%. Table 2 clearly shows that substantial disparities exist among the German federal

states. Four federal states did not offer any digitalization-related programs at all during the analyzed period. The highest proportion is 4.6% achieved by one federal state. Three other federal states offered further PE teacher trainings on digitalization with a share of three to four point 6%. The analysis of the further PE teacher trainings also shows that they are largely functionally oriented toward digital media. A reference to the personal-reflective dimension is not apparent.

The number of further PE teacher trainings held was set in relation to the different school levels in Germany. As described in the state of

research (chapter 2), a distinction was made between primary school, secondary level I, secondary level II and multiple school levels. The descriptive analysis of the different school levels shows that a slightly higher share (45% vs. 40%) of educations for multiple school levels are designed with digitalization-related content. In contrast, a quarter of further PE teacher trainings primarily designed for secondary level II (25% vs. 16%) include digitalization-related content. Contrariwise, further PE teacher trainings with digitalization-related content rarely were designed for primary schools (14% with vs. 26% without). There were no differences targeted toward other school types, like secondary level I in terms of the educational programs with or without digitalization-related content. To conclude, the focus of further PE teacher trainings with digitalization-related content is directed toward later school levels.

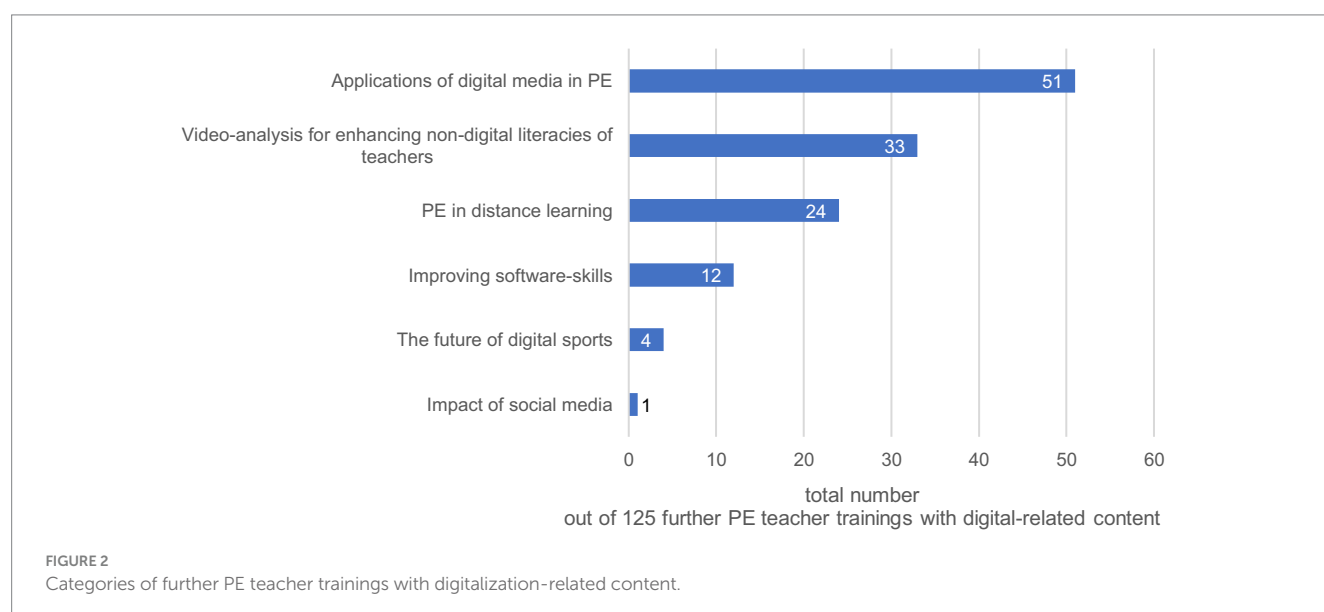
TABLE 2 Number of further PE teacher trainings with digital content in 12 federal states.

Federal institutes	Further PE teacher training with digital content	Sum	Relative number
	[n]	[n]	[%]
Schleswig-Holstein	10	218	4.6%
Hamburg	7	194	3.6%
Lower Saxony	16	445	3.6%
Rhineland-Palatinate	21	693	3.0%
Berlin-Brandenburg	10	394	2.5%
Hesse	46	1,996	2.3%
Baden-Wuerttemberg	12	1,014	1.2%
Thuringia	3	492	0.6%
Bavaria	0	705	0.0%
Bremen	0	11	0.0%
Saarland	0	94	0.0%
Saxony	0	70	0.0%
Σ	125	6,326	1.9%

4.2 Aspects of digitalization of the further PE teacher trainings with relation to digitalization

The majority of the further PE teacher trainings with digitalization-related content is related to applications of digital media in PE. The second largest category is represented by 33 events and is described as video-based movement analysis. Due to that category, 28 further PE teacher trainings are attributed to improve the sport-specific technique of the instructors. Five of these events deal with the objective of helping teachers recognize common errors and provide better feedback to students. PE in distance learning is the third most frequently addressed category with 24 events dedicated to it. They start to appear in 2020 due to the COVID-19 pandemic and were given the challenge of planning and conducting PE as distance learning because professional development in this area became imperative. A smaller number of events are dedicated to improving software-skills and “The Future of Digital Sports.” Only one event out of the 6,326 events was addressed to the impact of social media on children and adolescents (Figure 2).

A sub-categorization of the possible applications of digital media in PE shows that 21 out of the 51 events focused on movement visualization, movement analysis and movement reflection. 17 events focused on the use of specific apps. However, it is not specified which



applications were used. In contrast, only 8 out of 51 further PE teacher trainings focused on student-centered use of digital media. Only two courses focused on the acquisition of skills by students and only one out of 51 further PE teacher trainings focused on reducing teachers' workload by using digital media (Figure 3).

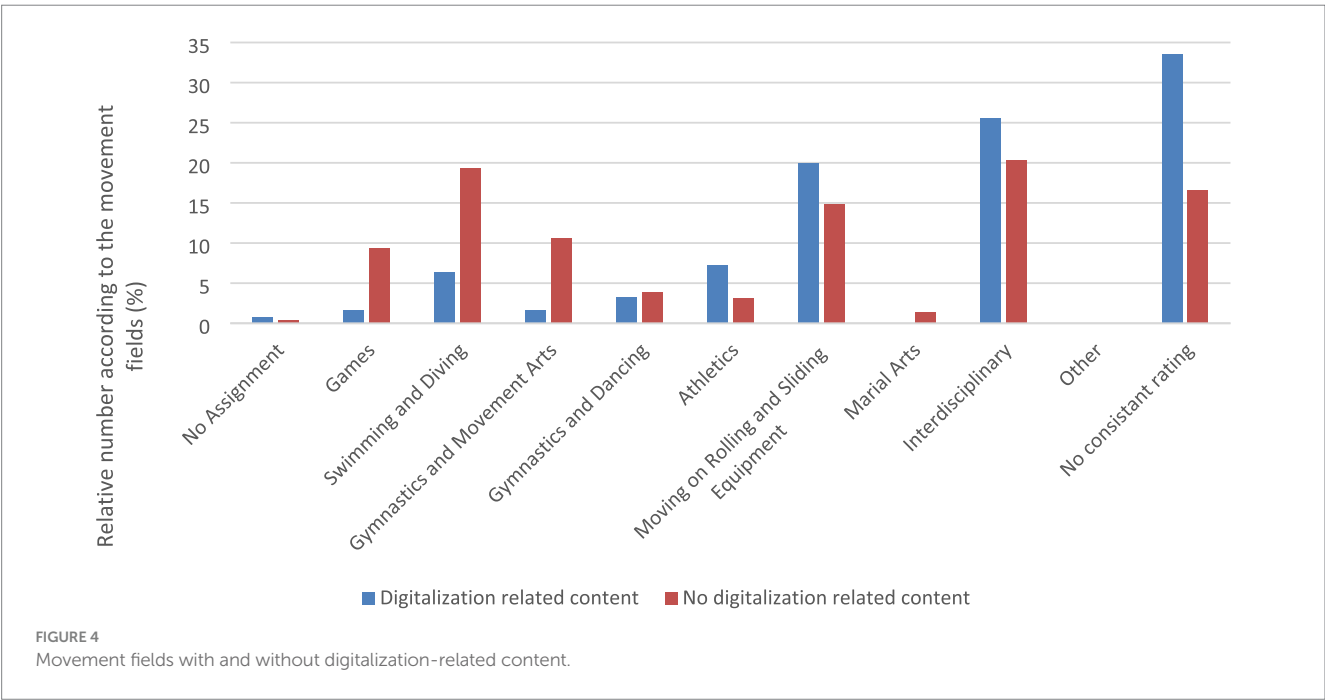
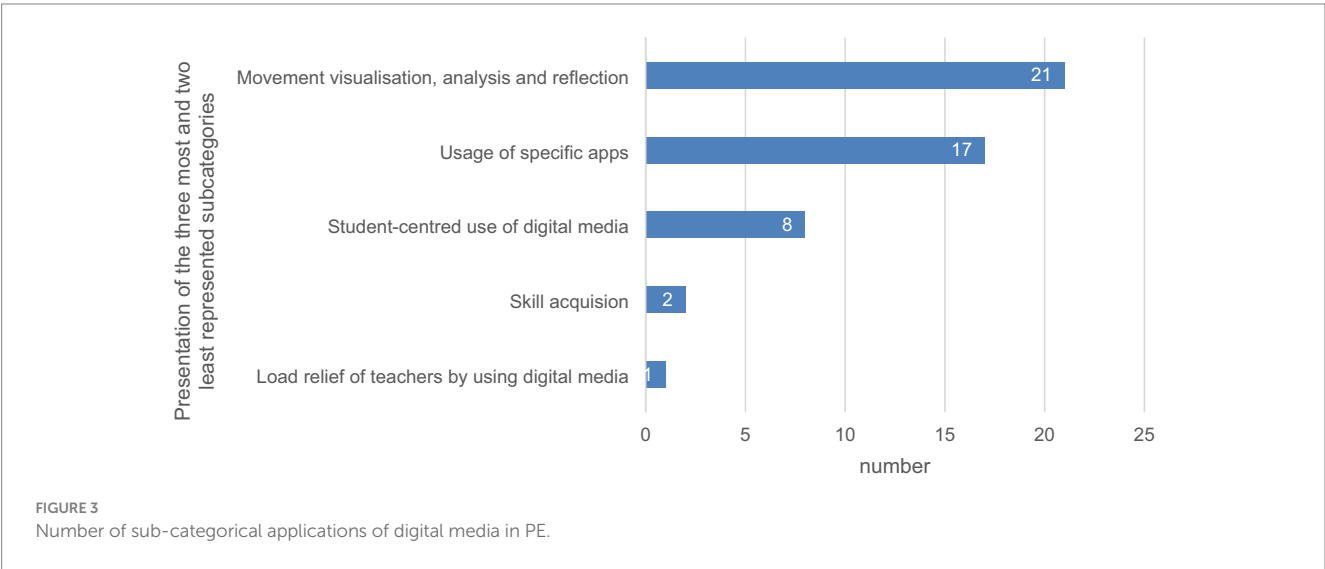
4.3 Movement fields addressed in the further PE teacher trainings

The analysis in terms of the addressed movement fields has shown that further PE teacher trainings are more often developed for overall physical activities (20.5%). The specific categories *swimming and diving* (19.0%), *movement on rolling or sliding equipment* (15.0%) and *gymnastics*

and *movements arts* (10.4%) are less frequently addressed. Furthermore, there is a lack of events in the categories *games* (9.2%), *gymnastics and dancing* (3.8%), *running, jumping, throwing* (3.2%) and *martial arts* (1.3%). 17.0% of the events were not clearly assessed as part of the independent rating. Accordingly, these events could not be clearly assigned to any category. The following figure shows the relative number of further PE teacher trainings with and without digitalization-related content in relation to the movement fields (Figure 4).

5 Discussion and conclusion

It can be stated that the significance of digitalization to the Federal Republic of Germany and the expectations placed on educational



institutes are not commensurate with the further PE teacher training content that is currently available. Out of the total of 6,326 further PE teacher trainings examined, only 125 address the topic of digitalization in a broader sense, including aspects of learning with digital media. Digitalization in a narrower sense, like learning about digital media with taking the personal-reflective perspective into account, is not addressed at all. This is problematic because digitalization in PE lessons can only be successful if it targets toward the realities of the students. This refers to a subject-specific ability to reflect on and criticize digital media (Redecker, 2017). In terms of specific aspects of digitalization, the use of video technology to movement visualization, analysis and reflection and the use of specific apps dominates further PE teacher trainings. However, pure video analysis in PE is not particularly new. Only the use of tablets allows a new approach to learning of movement: the shift from a passive-receptive role of the students to an active-productive role (Wendeborn et al., 2020). The passive-receptive use of digital technologies does not exhaust the transformative potential of digitalization in the context of education [Brueggemann and Frederking, 2024; Gesellschaft für Fachdidaktik (GFD), 2018]. Nevertheless, if pedagogy, digital technologies and subject-specific content are systematically coordinated the transformative potential of digitalization can be exploited (Wallace et al., 2023).

These transformative potentials are particularly evident in connection with the special aspects of the movement fields of PE. For example, the use of technologies such as video analysis of human movement during the movement field *swimming or moving on rolling and sliding equipment*, does not contribute itself to the acquisition of digital competencies. It requires a didactic and methodological framework and a topic-specific preparation for teaching in order to utilize the potential of digital transformation. The digital transformation in education can be described as the realignment of educational models using digital technology (McCarthy et al., 2020). The analysis of further PE teacher trainings shows no consistency in the movement fields. Digitalization is addressed very differently here. For the analysis period, it appears that digital technologies are more an additional challenge and contribute less to relieving teachers. Technical challenges appear to be too high and the functionality of digital technologies not sufficient for regular lessons (e.g., in the movement field of swimming and diving). Furthermore, teachers' lack of competence in using or teaching through digital technology constitutes an additional obstacle to the learning of both teachers and students (Bodsworth and Goodyear, 2017). Consequently, PE lessons could become less predictable for teachers due to the use of digital technologies (e.g., due to unforeseeable technical faults). The analysis also shows that digitalization is primarily an interdisciplinary topic. However, offering digitalization as a cross-cutting topic is problematic due to the lack of reference to the movement fields. This is problematic because the use of digital technology in PE lessons is only practicable for teachers if there is a clear link to the movement fields of PE.

There are a number of limitations to the results of this analysis. Firstly, this is a dataset from 2021. In the meantime, a lot has changed in Germany with regard to digitization in education. This will be discussed later. Secondly, data is only available from 12 of the 16 state institutes and one of the missing federal states is the most populous in Germany. Thirdly, it is not possible to provide information on the quality of the further PE teacher trainings, the expertise of the trainers, the number of participants or the results. Furthermore, the results of

evaluations of these programs are not available or accessible. In addition, there is (still) no mandatory further teacher trainings in Germany.

With reference to the research aim of investigating the integration of digitalization content in further PE teacher trainings across Germany, it can be summarized that, based on the results and the limitations reported, the third phase of PE teacher trainings has remained largely ineffective in developing digital competencies. This is essentially in line with the findings of Sagafe and Wendeborn (2023), who already stated this with regard to the first phase of PE teacher training. Although digital media has been integrated into some subject-specific didactics and has been tested in practical phases, a lack of comprehensive and mandatory curricular anchoring persists (CHE Centrum für Hochschulentwicklung, Stifterverband, Bertelsmann Stiftung & Robert Bosch Stiftung, 2018). Consequently, a substantial proportion of prospective teachers begin the second phase of their education with inadequate digital competencies. Moreover, the provision of 6.5 billion in federal funds exclusively for the material and technical equipment of educational institutions (a digital pact for schools 2.0 is under discussion) should be viewed critically. The primary objective of digital education can only be achieved if the governments of the federal states utilize the financial resources to effectively facilitate the acquisition and subsequent utilization of digital technologies. The federal government's initiatives have not been sufficiently exploited so far, thereby preventing the operational implementation of the central demands outlined in the SMK, KMK and BMBF strategy papers. Even if the financial resources were fully utilized the challenges of digital education would remain unresolved. It is only possible to utilize the requisite digital technologies adequate if teachers are digitally competent (Sagafe and Wendeborn, 2023). In order to achieve a successful digital education, it is essential that digital media become a mandatory component in all three phases of teacher training. The implementation of binding standards, defined by the federal government beyond the borders of the federal states could ensure the strategic implementation of the KMK guidelines. The realization of this strategy could be facilitated by the establishment of target agreements between federal states and educational institutions (CHE Centrum für Hochschulentwicklung, Stifterverband, Bertelsmann Stiftung & Robert Bosch Stiftung, 2023).

To address this complex problem, the transfer center of the competence network (learning:digital) has started its work. It focuses on digital and digitally supported teaching in schools and further education. The BMBF is investing up to 205 million euros in research, development and transfer until 2026 and is making a substantial contribution to the further development of the training landscape for German teachers [Bundesministerium für Bildung und Forschung (BMBF), 2024]. Due to this fact, it is particularly important to possess subject-related digital competencies in order to translate the topic in subject-specific manner. This subject-specificity is closely linked to the requirements of a functional and personal perspective on digital sovereignty as a goal of subject-matter education (e.g., critical reflection on digital media in the context of PE). The functional perspective of subject-matter education describes subject-specific learning and teaching as dimensions of competence and knowledge, whereas the personal perspective of subject-matter education strives to promote a critical-reflective position of one's own relationship to oneself and the word (Bayrhuber and Frederking, 2024). Additionally, the personal perspective on subject-matter leads to a more successful functional subject-matter education (Bayrhuber and Frederking, 2024).

Regarding to this, teachers must be able to link the use of digital technologies to specific teaching situations. Further PE teacher trainings have to clarify how digital competencies are developed professionally. Teachers must also be able to understand how subject-specific skills can be developed through the use of digital technologies. In this regard, the mentioned SEPACK.digital offers a valuable framework for the future design of further PE teacher training, as it emphasizes that digital education must go beyond the functional use of digital technologies and systematically integrate subject-specific as well as personal-reflective engagement with the digital world. This is the only way to counteract findings such as those from the ICILS studies.

Digital sovereign action by PE teachers can only be achieved through a sufficient number of PE teacher trainings in the different phases of teacher education. Following this, further PE teacher trainings concerning digitalization must be aligned with the specific focus of PE. Therefore, digital media should not only be seen as tools, but rather have to be placed in the context of the ethical and personal challenges of digital transformation. However, as already explained, this is not given in the first and third phases. Consequently, it is difficult for PE teachers to acquire necessary digital competencies. Without these competencies, teachers cannot fulfill the educational mission.

It can be assumed that only digitally versed teachers are able to assume advisory and multiplication tasks at schools and further education institutions (Redecker, 2017). Students cannot participate confidently in a digital society with a deficit in digital competencies. The need to acquire digital competencies arises from the increasingly digital world in which students live. Accordingly, fundamental socialization processes in connection with the physical and sporting development of children and young people are influenced in the digital space. This includes topics such as the representation of the body in social media, the critical reflection of body images and the (manipulated) representation of supposed body ideals. Given that children's and young people's life take place in the digital space, it is regrettable that the impact of social media with the presentation of body-related content is almost not addressed in the more than 6,000 further PE teacher trainings (Figure 4). This means that no reference is made to the reality of the needs of young people in the process of self-development.

In final conclusion, the study marks both a theoretical and a practical contribution. Theoretically, SEPACK.digital provides as a basis for the further PE teacher training concepts a suitable framework that connects the use and the reflection on digital media and encompasses both a reflective understanding of its functional and societal consequences of the digital and enabling (Frederking, 2022b). As a result, evidence-based development, evaluation, and implementation of further teacher training modules to promote teachers' digital competencies must take place. Further PE teacher trainings must ensure that the socially relevant topic of digitalization becomes a topic for education, schools, and teaching.

6 Prospective view

In order to prevent digitalization from failing in German schools, further teacher trainings should be developed that are targeted to the needs and interests of teachers for digital and digitally supported teaching (Tannehill and MacPhail, 2017). From the educational policy side, the various position and strategy papers from the KMK, BMBF

and GFD form a suitable basis for this. Funding initiatives such as the Digital Pact for Schools and the federal government's investments in research, development and transfer also make an important contribution to this. From a strategic side, it is crucial to promote specific research that is relevant to teaching. To achieve this, subject-specific needs must be identified and transferred into the development of appropriate teacher training concepts. The results of this research can enable PE teachers to practice in a digital sovereign way.

Author contributions

FB: Writing – original draft, Methodology, Visualization, Conceptualization, Funding acquisition. DB: Formal analysis, Methodology, Visualization, Conceptualization, Writing – review & editing. HW: Writing – review & editing. GR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft. TW: Writing – review & editing, Methodology, Project administration, Supervision.

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