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ARTICLE

Acting self-determinedly and critically in a post-digital future? A critical review on digitalisation in music education

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ABSTRACT

In this article, we will ask how music education can prepare learners for future-making in a post-digital world. Starting with a critical literature review we identify characteristic logics and central topics in the discourse on digitality in music education: the polarising argumentation in dichotomies, the tendencies of deterritorialization in post-digital practices, the focus on smart mobile technologies, the new awareness and changing role of things and musical instruments, and the strong interconnection to popular music (education), the upcoming discussion on creativity, artificial intelligence, hacking and sustainability, and the debate on the high demands on teachers, that are connected to the use and implementation of digital technologies in music education. On this basis we discuss the potentials and constraints that occur in music education due to the transformation to a post-digital world. Further, we discuss future steps for research and teacher education, and different practice contexts in the field of music education which help to enable learners to act in a self-determined way, and critically, in a post-digital future.

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Introduction

Like many fields of education in our days, music education is facing challenges that are strongly interconnected with central social issues: Demographic changes, the climate crisis, re-nationalisation tendencies, pandemics, migration movements, and the transformation to a post-digital society. This creates a pressure to act that can trigger constructive transformation processes but can also lead to conservative trends and to an increase in social tensions. However, the question as to how culture and education will develop and how it could be reconfigured to prepare learners to meet the challenges of today and tomorrow

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– actively, participatory, self-determinedly and critically – seems to be more relevant than ever (see Kultusministerkonferenz [KMK], 2018). In music education a debate began recently on how music education could be reconfigured for future-making (e. g. Buchborn et al., 2022). In this article, we will focus on one of the central questions connected to transformation processes driven by social change. We will ask how music education can harness the potential of technologies and face the challenges that arise from the transformation to a post-digital world in order to prepare learners for future-making. We analyse the potentials and challenges associated with the digitalisation of music education contexts and discuss how music education can prepare learners for future-making in a post-digital word.

In recent decades, digital technologies have transformed many aspects of our lives, including the way we create, consume and learn music. This technological change also had a strong influence on the field of music education. The use of digital tools and resources has become increasingly common as teachers and students alike embrace the potential of technology to enhance their musical learning experiences. From online music lessons and digital practice aids, to music production software and collaboration platforms, a wide range of digital tools and resources are now available to music teachers and students. During the global COVID-19 pandemic, the "digital 'turn' in music education" (Camlin & Lisboa, 2021, p. 1) once again picked up speed. However, as with any new technology, the integration of digital tools and resources into music education presents challenges and raises important questions about the role of technology in the music learning process.

It is a central question whether music education, in theory and practice, is ready to provide learners with opportunities to build up the key competences needed to face this digital turn – actively and critically, and in a self-determined and participatory way, – in a post-digital world (KMK, 2017, 2021). It is hard to build up these required competences in everyday life and in established institutions or traditional educational settings. Music education is, therefore, facing new challenges, especially regarding the discourse on musical participation and digital maturity. A task for the future lies in the development of innovative educational formats and concepts that enable active participation in shaping a digitalised (music) world and the acquisition of general and music-specific competences.

Against this background, we analyse the discourse on digitalisation in music education in order to determine where we stand and to begin to discuss perspectives on where to go. Starting with a critical literature review looking at the discourse – mainly from the perspective of music education in Germany – we identify central potentials and constraints and provide a solid needs analysis. On this basis we want to point out that the concepts are essential in order to give children, young people and adults more agency in the post-digital world. We will further illustrate that the maker education approach is an example that fulfils this educational need, as it particularly focuses on aspects of agency, self-empowerment and finding creative solutions to situation-specific problems and needs when dealing with technology. Maker education and hacking is enabling students, artists, teachers and citizens to have a self-determined, interest-driven, creative approach to music technology. By experimenting, tinkering, developing and playing, digital and musical maturity is promoted and, at the same time, an (experimenting and learning) space for collaborative and creative music practices is initiated. Making can also promote synergies between different educational institutions/stages as well as between formal, informal and non-formal educational offers.

A critical literature review

For this critical literature review, a comprehensive search was conducted using academic databases such as the German platform *Fachportal Pädagogik* as well as *Google Scholar*. In the first step we mapped the field by searching with global keywords such as "music education", "digitalisation", "technology". On the basis of our results, we identified trends and common topics in the discourse that delivered more specific search keywords such as "post-digitality", "mobile smart technologies", "digital musical things", "Digital Audio Workstation (DAW)", "New Interfaces for Musical Expression (NIME)", "Digital Musical Instrument (DMI)" etc. As a second stage, we used these keywords to follow the discourse through a deeper search on these topics raised in the literature. This enabled us to gain insights into sub-themes in more detail. In the results section we will map the discourse according to these sub-themes that characterise discussion on digitalisation in music education.

Our observation is that, particularly in the last 20 years, the topics related to digitalisation are discussed broadly in the field of music education. Furthermore, in recent years, the discourse has become more and more differentiated, also in relation to international perspectives. For this reason, we have decided to include a dedicated selection of literature in this critical review, also because we wish to focus on the national state of affairs in Germany. Our guiding question already starts from the assumption that education should enable a participation-oriented, self-determined, critical and active approach; – this assumption is strongly connected to recent national discussion on education (see KMK, 2017, 2018, 2021). As we positioned ourselves in this framework, the characteristics and the specific conditions, goals and conventions of the German education system became visible. This led us to the decision to focus our sample mainly on the German discourse. However, as the debate on digitalisation and music education in Germany is interrelated with the international discourse in many ways, we have also included several selected international studies that influenced or are connected to the German discourse. This allows us to provide a broader and comprehensive picture.

Results

In the following section we will show that we were able to identify different topics that are central in the discourse on digitalisation in music education. Regardless of the topics, the argumentation structure in many contributions is characterised by dichotomies. Central topics are the tendencies of deterritorialization that come along with post-digital practices, the focus on smart technologies, the new awareness and changing role of things in musical practice, the expansion of the concept of the musical instrument and the strong interconnection to popular music (education). Further, we were able to identify topics that point to the future: The discourse on creativity, artificial intelligence, hacking and sustainability. We close our review with another overarching theme that we identified: The debate on the high demands on teachers, that are connected to the use and implementation of digital technologies in music education.

From heated polarisation to post-digitality

Common to the discourse on the use of digital technologies in music education is the argumentation in dichotomies. Authors often distinguish between technology and non-technol-

ogy. Espeland already noted in 2010 that the critics of technology consider the "essence and qualities in music education to consist of practical, aesthetic, and expressive activities involving body and mind" (p. 130), that might be threatened by the use of technology. He continues to explain that, according to advocates, music technology could have a positive impact on future music education as it can increase access and opportunities for individuals to engage in and receive education in music (Espeland, 2010). In a discourse-analytical comparison of three exemplary music education articles on technology and music education, Sachsse (2021) shows that the field of tension described above can also be observed in current literature. According to him, the main lines of discourse run between pairs of terms such as sensuality versus non-sensuality, innovation versus tradition and digital versus analogue (Sachsse, 2021). However, thinking in dichotomies is also criticised, especially in recent publications. A number of researchers warn that these polarising argumentations prevent a proactive discourse on digitalisation in society as a whole. This can endanger the status of music in school, as it makes it much more difficult to connect with current academic and educational policy discourses (Ahlers & Godau, 2019; Brunner & Treß, 2021).

Additionally, Clements (2018), and other authors, point out that such polarisations have become superfluous and anachronistic in view of a declared departure into a post-digital age (Ahlers & Godau, 2019; Cramer, 2015). According to Bettinger (2019), this shift of paradigm is characterised by the ubiquity and hybridity of old and new media technology infrastructures in many areas of society. He states that the visionary talk of the disruptive potential of digitalisation therefore lags behind the actual development (Bettinger, 2019). With regard to music technology and music education, Clements (2018) argues that the aforementioned dichotomies are, therefore, becoming increasingly useless as categories for classifying and categorising music-specific media and technologies or related music-making and teaching practices. In contrast, the social situatedness and hybridity of a culture of digitality (Stalder, 2016) and the (musical) practices that accompany it have recently been emphasised (Clements, 2018).

Deterritorialization of music education and related practises

The fact that digital technologies were already integral agents in everyday praxis – not only in music education – opened up many possibilities for teaching and learning during the global COVID-19 pandemic. In times of lockdown and distance learning another characteristic aspect of the post-digital age became clear: Musical learning and practice is increasingly shifting towards decentralised and network-based communication channels. However, music educational implications of music learning and teaching in online communities were discussed much earlier than this, owing to the increasing use of online video platforms and social media channels with music educational content (Waldron, 2013a, 2013b); this aspect has recently gained importance in the discourse. In a mixed-method study, Weyel and Lehmann-Wermser (2020) examine informal digital learning environments and find that the social video platform YouTube, for example, is used both for the reception of music and for the self-organised acquisition of musical knowledge. The increasing networking of agents can also be observed in the field of technologies. Turchett et al. (2020) suggest the paradigm of the "Internet of Musical Things" and define this as "networks of computing devices embedded in physical objects (musical things) dedicated to the production and/or reception of musical content" (p. 1). Borchert et al. (2022) analyse different music-making formats, workshops and (online) educational prac-

tices in the context of an online music education conference. They conclude that there is an extensive interconnection of auditory and visual dimensions in online music formats (Borchert et al., 2022). Likewise, the authors note that digital and network-based forms of music-making often allow for control over the temporal dimension of musical interaction that previously seemed impossible (Borchert et al., 2022). In addition, they point out that the boundaries between production and consumption of musical content are becoming increasingly blurred (Borchert et al., 2022). Camlin and Lisboa (2021) also notice a general "convergence between recording and performing fields of music" (p. 134). To what extent the "disruption" (Camlin & Lisboa, p. 129) caused by the COVID-19 pandemic has also had a lasting effect on the use and inclusion of post-digital music technologies in music teaching remains an open question. Studies with a cross-curricular perspective on digitalisation processes in German schools do not suggest that there has been a clear sustainable effect (Eickelmann et al., 2020; Mußmann et al., 2021, p. 239).

Mobile smart technologies in music education

When considering the production of music, the increasing independence from location-based technologies such as a recording studio is being accelerated significantly by so-called 'mobile smart technologies'. Since Apple first introduced the iPhone in 2007 and the iPad in 2010, mobile smart technologies have become a frequently used tool in music education. The examination of mobile technologies is, therefore, also a central topic of music education discourse and of research and development projects in German-speaking, and other countries. A prominent example of this development is the collaborative project *MuBiTec: Musikalische Bildung mit mobilen Digitaltechnologien* (Godau et al., 2019). Similar to a large number of other international research projects in the field of music education technology research (Ahlers & Godau 2019), *MuBiTec* has a clear focus on digital mobile technologies (e.g., the music-specific use of smartphone and tablet apps). However, despite the widespread use of mobile technologies in music education and their central position in project work and research, their use in music education contexts is controversial. The new possibilities of mobility, for example, are generally viewed positively. Eusterbrock (2023) points out that such technologies can lead musicians to look for "specific places to make music with apps to get them into the state of mind they need for their creative process" (p. 61). He, thus, describes app music practices as "[m]usical technologies of the self" that "involve a complex interplay between music, place, and various aspects of the self, and they not only function as self-care and self constitution, but also as a creative strategy" (Eusterbrock, 2023, p. 61). With regard to app music practices, the importance of the design of music-specific software interfaces is becoming the focus of academic interest. This aspect is discussed more controversially. While Eusterbrock et al. (2021) emphasise the ludic qualities that can go hand in hand with the affordances of the app design, Simon (2020) and Bell (2015a) critically point to the simplification and reduction of operating options that accompany many music app interfaces in order to enable the most low-threshold and joyful musical practice possible. If technology makes music more accessible or not also remains questionable. Whether or not the respective technologies facilitate access to music, and under what conditions, also remain open questions. From an inclusion-oriented perspective, Godau (2018) draws attention to the fact that, in principle, all types of musical instruments come with certain possibilities and also limitations. With regard to the spectrum of music apps used in music classrooms, he suspects a monopolising tendency by

Apple's Garageband rather than a broad diversity of apps (Godau, 2018). As the majority of all educationally motivated app music projects are limited to this one app he states that this monoculture or canonisation tendency contradicts the argument of multiple approaches (Godau, 2018). Niediek and Gerland (2022) draw attention to the potentials of music apps, especially with regard to inclusion-oriented requirements, and point to the high presence of digital media in everyday life, the comparatively easy method of sound production, and the convenient integration into the student's lifeworld experiences. However, despite a generally positive view of the use of music apps in music lessons, they indicate that not all adaptation problems between material artefacts and musicians can be solved by individual configurations according to the current state of technologies (Niediek & Gerland, 2022). With regard to music-specific app use in informal learning contexts, Lehmann-Wermser et al. (2022) make it clear that the actors in their study often lacked the music- and technology-related competences to achieve lasting and motivating learning outcomes. They conclude that a naïve exposure to apps, which presupposes these music- and technology-related competences, is not very effective (Lehmann-Wermser et al., 2022). Further, Clements (2018) observes that the use of mobile technologies is leading to changes, especially with regard to the role of the body in music-making processes. She notes that the generally observable tendency towards the use of music apps in music education practice entails a potential neglect of "kinetic whole-body engagement, motion, and movement" (Clements, 2018 p. 60), which, according to her, is tantamount to a massive restriction of the scope of action in music education. Godau (2022b) in contrast, from a post-phenomenological perspective, explains that the control of the touchscreen of a smart device also allows for ludic modes of world appropriation and can, thus, be read as an expression of a particular experience of embodiment, intimacy and truthfulness.

The valorisation of things in musical practice and the expansion of the concept of the musical instrument

The hybridity and seamless connection of different analogue and digital technologies already mentioned above is particularly evident in human interface research on "Digital Musical Instruments" (Mirando & Wanderley, 2006) and New Interfaces for Musical Expression" (Jensenius & Lyons, 2017, p. xii). Both terms refer to a variety of different technology-supported sound generators that can be defined both by the type of sound generation (digital sound synthesis in the case of DMIs) or by the use of novel and unconventional operating concepts ("interfaces" in the case of NIME). The relationship between the two, initially, independent units for sound synthesis and control is first determined by certain "mapping strategies" (Mirando & Wanderley, 2006, p. 3). In this way, for example, a camera sensor for movement detection can be connected to a software synthesiser that produces specific sounds. The mapping concept could then, for example, link the movements of a person's arms with the volume, and those of the head with the pitch of the synthesized sound. Pessoa et al. (2020) state that such innovative music technologies generally hold great potential for the field of music education since, on the one hand, they allow low-threshold and prerequisite-free music-making and, on the other hand, they enable multifaceted, appealing and, thus, strongly motivating sound-aesthetic results. The authors also point to other positive factors such as portability, low acquisition costs and adaptability to individual requirements and needs (Pessoa et al., 2020). They identify particularly promising fields of practice in the area of sound art, sound design, multime-

dia performance practice, and in the promotion of cultural diversity through the critical connection of novel and traditional music-making and performance practices, as well as sound aesthetics (Pessoa et al., 2020).

So far, such new interfaces and musical instruments have been used increasingly in the field of inclusive and special needs music education, as the new operating concepts can be adapted to the needs of people with disabilities (Frid, 2019). In an interview study, Förster (2022) shows that teachers in this field of music education are open to the use of new technologies and interfaces but, explain that their lack of knowledge and experience are obstacles to their use in the classroom. He, therefore, sees dealing with new interfaces and digital musical instruments already included in teacher courses as a priority, and advocates students' participatory involvement in the development and design of such interfaces in order to ensure the best possible fit with aesthetic preferences and individual needs (Förster, 2022, p. 75). The German research project *MIDAKuK* also investigated the potential of new interfaces and music technologies and pursues research on material artefacts, devices and interfaces involved in musical and sound-artistic processes (Jörissen et al., 2019). In this context, material-digital transformation processes are investigated starting from digital musical instruments or 'music making things' ("MusikmachDinge", Ismaiel-Wendt, 2016, p. 3) among young people (novices) and professional musicians. As in the field of app music, here, the researchers are also asking about the relationship between power and affordance within hybrid digital-material music-making things, which they consider to be empirically unexplained to date (Jörissen et al., 2019). Although *MIDAKuK* investigates the potential of innovative technologies here, they focus on commercially available music technologies (Jörissen et al., 2019) that correspond to certain application purposes, performance styles and musical practice fields and the norms and expectations that apply to them (e. g. pad controllers for percussive playing for beat production and performance). Thus, the following statement by Clement (2018) also applies to these digital music practices: "[T]he creative process through which users can engage with and through [...digital technologies] is predetermined by their design and interface" (p. 57).

Due to the high significance of the design of music technologies in the age of post-digital music practice, it is evident that an expanded concept of the musical instrument has established itself here; this is constantly evolving in relation to technological innovation. Thus, the recording studio itself – or its digitised version, the Digital Audio Workstation (DAW), which can be operated on almost any digital device, whether smartphone, laptop or desktop computer – is now considered a fully-fledged musical instrument (Bell, 2018; Pierard & Lines, 2022). While Bell (2018) emphasises, in principle, the high music educational potential of "DIY Recording and Informal Learning Strategies" (p. 180) he identifies gender-related issues in this field and pointed out earlier (2015b) that a "male-centred legacy of recording technologies" (p. 138) is particularly evident in this field. As such, the author is critical: "[W]e can safely assume that women, especially minority women, have in most cases had little involvement in the development and refinement of DAWs and other computer-based technologies for music production" (Bell, 2015b, p. 139).

The intertwining of popular music education and music technology

Since the engagement with popular music phenomena and forms of practice has become a central area in music education, the close interconnection of popular music education

and the use of (digital) music technologies are discussed on a regular basis. Till (2017) points out that "[p]opular music today makes extensive use of the latest digital technologies, from the computer technology used by DJs and producers, to the social media, smartphones and tablets used for dissemination and reception of music" (p. 25). The extended possibilities with regard to the processing of recorded audio material through digital technologies have led to a significant expansion of the notion of music itself. Instead of talking about notes or tones, the term 'sound', which also has its origins in popular music research, is becoming more and more established (Brøvig-Hanssen & Danielsen, 2016). With the term "sound-based music" (Landy, 2012, p. 3), for example, Landy emphasises the digitally supported integration of all sounds and noises in musical practice and the potential of creative design of soundscapes and sound installations (see also Therapontos, 2013).

Till (2017) emphasizes that the strong connection of pop music and technological innovations also goes hand in hand with close relationships to the music industry. While partnerships and collaborations like this are positive for developments in many fields of pop music, they are also criticised – especially in the educational context (Benedict & O'Leary, 2019). It is viewed with concern that cultural innovations are dependent on industrial developments and, thus, indirectly, also on economic interests. One of the main reasons why state schools in Germany are not allowed to collaborate directly with partners from the business sector is to avoid non-transparent advertisement and product placement in schools.

Another critical aspect is the extensive and ongoing marginalisation of women and ethnic minorities at the intersection of popular music, music technology and music education. Hopkins and Berkers (2019) show, through an interview study with female music technology students, that women are often "a token in a mostly-male classroom" (p. 54), taught exclusively by men.

Topics pointing to the future: Creativities, sustainability, hacking and AI

A general observation reveals that the majority of literature dedicated to the use of technology in music education is located in the field of creative music making. Burnard (2009) emphasizes the close relation of creativity and technology in music education and points out that both are to be considered "Critical Agents of Change in the Work and Lives of Music Teachers" (p. 196). She also proposes that classroom enquiry should focus on learners' different perspectives both in and out of the classroom, taking into account institutional and home factors that contribute to creative learning and new models of teaching with technology (Burnard, 2009). Furthermore, she marks a desideratum for the development and sharing of effective didactic strategies for the use of music technology in music lessons in order to promote creativity and identify teaching and learning strategies that are suitable for practice (Burnard, 2007). Since these early contributions to the discourse, different aspects and techniques of music production in educational contexts became subjects of research. Godau and Haenisch (2019) analyse pop music songwriting processes in music lessons; Kattenbeck (2022) examines processes of beatmaking as a form of creative use of already existing sound material in informal contexts; Duve (2022) investigates the sociomateriality of digital group composition processes by means of sample-based audio software.

However, the increasing influence of digital technologies and their associated design-specific affordances on all areas of daily life, including education, is clearly in tension with values such as self-determination, autonomy and freedom of choice that are central for creativities and musical practices (Benedict & O'Leary, 2019). This is particularly true in the field of sustainable education, which contradicts the image of digital technology in education as an "inherently forward-looking and optimistically minded endeavour" (Selwyn, 2021, p. 497). The high demand for resources in terms of mass equipment, maintenance and updating of the respective technologies in educational institutions is particularly at odds with the goals of sustainable development.

According to several authors, a promising approach to music technologies in music education seems to be the maker education (Hughes & Kumpulainen, 2021). Hein (2017) highlights the music education potential of MakerSpaces as visionary informal learning spaces that could enable cross-generational and cross-institutional learning. The creative cannibalisation of discarded music technologies also opens up possibilities for education for sustainable development (Collins, 2020). Godau (2022a) sees a possible path towards more self-determination in "Hacking Music Education" (p. 52). In his opinion, this approach is one answer to regaining more control in the use of post-digital music technologies in the field of music education. Similarly, Benedict and O'Leary (2019) ask: "How might a shift from using music technologies created by others to creating and using music technologies shape music making and learning?" (p. 37) and invite music teachers "to explore the many creative possibilities that could arise through students' self-creation and self-modification of music technologies" (p. 38). First attempts at integrating such approaches for teaching technological pedagogical content knowledge and for increasing technology acceptance and student motivation in teacher training programs have already been made (Spieker, 2020). In this context, Campreguer França et al. (2021) emphasise, in particular, accessibility and the inclusive nature of opportunities for women and other underrepresented groups to gain access to self-determined music technology encounters. To date, whether, and under which conditions, such promising approaches can also be adapted for general music education, and what possibilities result, remain open questions.

Using the rich potentials of the technology while critically reflecting on the (power)relation of the agencies of human and non-human actors will also be the central challenge when bringing artificial intelligence (AI) into music education. The future relevance of artificial intelligence is one of the most current and controversial topics in the field of technology use in music education. Even though there are only isolated studies available, mainly from Asia (Shang, 2019; Yu et al., 2023), the first national funding lines of the Ministry of Education in Baden-Württemberg already indicate that the use of artificial intelligence will play a significant role in music teaching in the future.

Use of technology in music education: High demands on teachers

Another aspect that is addressed in many ways in the literature, relatively independently of specific technologies, is the high demands on teachers if they are to make effective use of technologies in music lessons (Gall, 2017). Bell sees, for example, the need for teachers to create a learning atmosphere "in which learners go beyond simply using music technologies and retroactively navigating their pre-programmed biases to avoid perpetuating a simplistic user mentality. Instead, music educators must engage their students in ac-

tivities of iterative technological tinkering that nurture a design mentality" (Bell, 2015b, p. 140). Similarly, discussing teachers, Himonides (2017) calls for "critical thinkers who are willing to polish old tools, forge new ones, creatively misuse existing tools, methods and processes, and creatively use whatever is at their disposal to facilitate learning and development" (p. 629). Burnard (2009) makes clear that such challenging demands on the teaching profession are not limited to the area of technology use. She, therefore, sees the task of teachers as being precisely linked to the relationship between the use of technology in music lessons and the creative learning processes (Burnard, 2009). In her view, more teaching-oriented, participatory and practice-based research should be conducted, which in the best case leads to "collaborative working environments where colleagues learn from each other" (Burnard, 2009, p. 196).

Digitalisation and music education: Between potentials and constraints

With regard to the use of digital technologies in music education, our literature review illustrates that rich potentials also include great challenges. Thus, in the discourse, a number of optimistic to euphoric positions can be found, which identify great opportunities for future pedagogy in digital technologies. Their accessibility is very often pointed out, especially in the context of the use of mobile music technologies and apps, since devices do not even have to be purchased separately, but can be installed and used on one's own smartphone. With regard to the sonic possibilities, the low-threshold possibility of achieving aesthetically pleasing results with little or no prior musical skills and knowledge, in a very short time, is particularly emphasised. At the same time, many applications seem to guarantee a direct connection to the lifeworld experience and aesthetic preferences of students through the provision of appropriate presets.

When considering diversity of sound, music cultures and practises, post-digital approaches are often associated with openness, inclusivity and participation. Modern music technologies only partially follow the traditional and eurocentric operating concepts of traditional musical instruments. The sound, which in many cases is synthetically generated, can be associated with different aesthetic musical cultures. Therefore, music technologies favour, in the best case, an opening of the understanding of music and the broadening of the aesthetic range of learners. Furthermore, the possibility to carry out musical learning processes in a decentralised and networked form is also described as a great benefit. Here, learning support on the basis of tutorials and in corresponding online communities plays a particularly important role. In this respect, the possibility of informal learning and related strategies in formal training institutions also seems promising.

However, our review also revealed that many authors see serious challenges and constraints. In many cases criticism is directly connected to the same thematic aspects that other authors discuss positively. On the one hand, the above-mentioned NIME or DMI carry potential for novel musical-artistic forms of expression, multimodal forms of interaction and associated musical learning processes. At the same time, innovative technologies bring special challenges for learners and teachers due to their unfamiliar and novel ways of functionality and operation. On the other hand, there is considerable criticism of the fact that, especially in the case of a large number of music apps, design-specific limitations stand in the way of a comprehensive music-making practice involving the whole body. Additionally, common music technologies are always developed for certain perfor-

mance formats and specific (production) styles and address certain users and buyers, so decisions made in product design become significant. It became clear, not only in this context, that, with the increasing use of music technologies, it is possible for manufacturers and software developers to gain more influence on educational practice. This inevitably raises the question of who has agency in music education, when and in which contexts, and where this is also prevented by (implicit) affordances of the respective technologies. Another limitation that became clear is that the inclusion of technology in the classroom often only addresses a certain selection of the student population. Equal opportunities and participation seem to be at risk, especially with regard to factors such as gender, but also social background and status.

Our review also revealed some 'blind spots' in the discourse. Despite the broad spectrum of music education literature on the topic of music technology and digitalisation, studies that are dedicated to the actual practice of music learning and teaching in classroom environments seem to be scarce. The main focus appears to be on the area of informal and extracurricular music practice with music technologies. Likewise, there is a lack of dedicated guidelines and design principles for music lessons in order to be able to plan and design the use of different music technologies in the classroom.

To put it in a nutshell: While diverse potentials are recognisable, the constraints indicate that the use of established and mainstream music technologies in music lessons is often accompanied by a massive restriction of the scope of action. In our view, this is clearly incompatible with the goals of a participation-oriented, self-determined, creative use of technologies mentioned in the introduction.

Conclusions and Implications

In the age of post-digitality, digital technologies are an integral part of everyday life in globalised societies. Therefore, digitalisation in many forms is also part of musical and music educational practices. Enabling teachers and learners to face this fundamental process of transformation is a central task of all fields of music education. It is a challenge for future music education to provide opportunities for learners – in all stages of their education from early childhood music education to teacher education and life-long learning – to build up competences, knowledge and skills to act self-determined and critically in order to co-create the post-digital world. The fact that digital technologies are already shaping and permeating the lives of all people in many ways is not only linked to challenges, but also to great opportunities. It opens up a wide range of possibilities in educational practice to link directly to the lifeworld of the learners and to develop participatory approaches. By acting as experts from the beginning and learning together, from and with each other, learners already experience their agency, and possibilities for action and scope in educational settings. In this way, they perceive themselves as co-creators at an early stage and can prepare themselves for a role as shapers of their own future.

In the field of pop music, numerous innovative creative and artistic formats have already been developed that can be linked to a participatory pedagogy oriented towards the lifeworld of the learners. The next steps are to develop technology-based learning and teaching formats for other areas, styles and practices, so that students can gain insight into the diversity of our contemporary musical cultures in the classroom. Furthermore, educational designs should be developed that are more open and inclusive by addressing the

interests and needs of all learners, regardless of their gender, social background and status, music cultural preferences.

The current narrowing of the discourse to app-based music-making also points to fields of action for the future: With regard to the possible uses of technologies in teaching, it is also important to orientate oneself towards breadth and diversity, and to make new technologies fruitful for music making, learning and teaching. This opens up new opportunities for a holistic and, thus, general educational concept of music practice with its performative component. Furthermore, it is important to take a critical stance on the appropriation of music lessons by consumer and growth-oriented logics and interests and to communicate this. This is the only way to ensure critical, self-determined action in post-digital societies.

Considering these general thoughts, we make the following proposals and end with a discussion of the implications in relation to reconfiguring music education. To face the lack of studies on the use of diverse music technologies in the classroom and the lack of empirically-based design principles for post-digital music education, we consider participatory and design-oriented approaches to classroom research to be particularly relevant and useful for the future of the discourse. Special attention should be paid to the students' perspectives, and the empirical analysis of the musical practice itself, as this remains largely unexamined in existing studies. In contrast, since the field of informal learning and music making with music technologies is often investigated, the question arises as to how a beneficial interweaving of informal learning processes can also be made fruitful in formal contexts. In our view, a particular challenge is the massively increased demands on teachers with regard to their own competences and to keeping pace with faster technological developments. Central concerns of teacher education and in-service training programmes should be how teachers can be inspired to use music technology and to deal with the associated opportunities and risks without discouraging them by massively overtaxing them. A significant aspect of this is the examination and critical reflection of neoliberal (market) logics and the commercial applicability of technologies. Instead of merely being at the end of the production chain, teachers should be involved in the development and design of music technologies for music education at a very early stage. This could also be done in a more or less close exchange with industry actors and in the form of designing and differentiating one's own openly accessible teaching materials (OER). Further developing research and teacher education like this should lead to innovative concepts of classroom learning and teaching, and prepare learners for future-making in a post digital world. In this context, we would like to emphasise the potential we see in creative concepts such as hacking and making. Corresponding approaches, which have recently been taken up in music education, should be further developed and implemented.

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